U.S. DEPARTMENT OF COMMERCE
National Technical Information Service
PB-271 994-T

Air Conservation. Volume 10, Number 4(54), 1976

Environmental Protection Agency, Washington, D C

Prepared for:

National Science Foundation, Washington, D C Special Foreign Currency Science Information Program

1977

BIBLIOGRAPHIC DATA SHEET	1. Report No. TT-76-54024/04	2.	3. Recipient's Accession No. PB-271 994-T
4. Title and Subtitle Air Conservation, Volume 10, Number 4(54), 1976			5. Report Date 1977 6.
7. Author(s)			8. Performing Organization Rept. No.
9. Performing Organization Name and Address Environmental Protection Agency Washington, D. C.			10. Project/Task/Work Unit No. 11. Contract/Grant No.
12. Sponsoring Organization Name and Address National Science Foundation Special Foreign Currency Science Information Program Washington, D. C.			13. Type of Report & Period Covered 14.

15. Supplementary Notes
Unedited trans. of Ochrona Powietrza (Poland) v10 n4(54), 1976, by Andrzej Skup. See also Volume 10, Number 3, PB-269 064.

16. Abstracts
The appraisal of operation of the dust control system equipped on the electric arc furnaces at the Baildon ironworks; The dust control problems in cement industry; The influence of some meteorological parameters on the spatial distribution of pollutants in the atmosphere; Analysis of the dust collection process on granular beds; Preliminary results of the studies on the efficiency of some demisting systems; Patent review; Review of papers.

17. Key Words and Document Analysis. 17a. Descriptors
*Air pollution, Translations, Air pollution control, Dust control, Spatial distribution, Atmospheric diffusion, Demisters, Reviews, Performance evaluation, Efficiency, Patents, Granulators, Cements, Aerosols, Poland.

17b. Identifiers/Open-Ended Terms

17c. COSATI Field Group

18. Availability Statement U. S. Department of Commerce National Technical Information Service Springfield, VA 22161	19. Security Class (This Report) UNCLASSIFIED 20. Security Class (This Page) UNCLASSIFIED	21. No. of Pages 76p 22. Price PC A04 MF A01

FORM NTIS-35 (REV. 3-72) REPRODUCED BY NTIS AND USCOMM-DC THIS FORM MAY BE REPRODUCED

PB 271 994-T

OCHRONA POWIETRZA
Vol. 10, No. 4 (54), 1976

TT 76-54024 4

Air Conservation

(Ochrona Powietrza)

TRANSLATED FROM POLISH

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

PUBLISHED FOR THE U.S. ENVIRONMENTAL PROTECTION AGENCY AND THE NATIONAL SCIENCE FOUNDATION WASHINGTON, D.C., BY THE POLISH SCIENTIFIC PUBLICATIONS DEPARTMENT OF THE NATIONAL CENTER FOR SCIENTIFIC TECHNICAL AND ECONOMIC INFORMATION WARSAW, POLAND 1977

Translation of No. 4, 1976 'Ochrona Powietrza,' bimonthly devoted to the atmospheric air conservation, an organ of the Polish Society of Metallurgical Engineers, Katowice. Published by Publishers of Technical Periodicals for Polish Federation of Engineering Associations (NOT), Warszawa

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Unedited Translation

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Available from the U.S. Department of Commerce, National Technical Information Service, Springfield, Virginia 22161

Krauss, U., Mędrala, A.

THE APPRAISAL OF OPERATION OF THE DUST CONTROL SYSTEM EQUIPPED ON THE ELECTRIC ARC FURNACES AT THE BAILDON IRONWORKS

(Ocena działania instalacji odpylającej elektryczne piece łukowe w Hucie Baildon)

A new dust control system that serves four electric arc furnaces of capacity 8, 10, 15, and 35 t is discussed. Operation of this system is evaluated and conclusions are made as to a further reduction of dust emission on the basis of measurement results conducted in two series as well as on the basis of operational observations of the system.

A new dust control system has been put on stream in May 1975 at the Baildon Ironworks. The system has been designed by the Biprohut Metallurgical Industry Designing Office in Warsaw. The project is designed to control exhaust gases from four electric arc furnaces of a capacity of 35, 15, 10 and 8 t, in which oxygen is used for steel refining. The paper reports on the specifications and performance of operation of the system on the basis of the measurements and operational observations made.

Specifications of the Dust Control Equipment

The dust control station serving the steel-melting shop of the ironworks in point operates on the basis of a dry collection technique. The system is composed of the following major units:

- hooding system,
- a thin-walled cooler,
- a 14-chamber fabric filter,
- 3 low-speed medium-pressure fans of a capacity of 83,000 m^3/hr each, rated at 6000 N/m^2 and 990 rpm,
- a steel stack 40 m high,
- dust disposal and pelletizing unit,

A direct capture of the exhaust gases from the furnaces, i.e., by means of a fourth opening in the furnace roof, is provided merely on the 15- and 10-t furnaces. In the Stein-Rubaux 35-t furnace, in view of its specific design, no direct hooding could be made, but a hood attached to the steel-shop roof. The 6-t furnace is equipped with a direct hood overhead. The dust control system under discussion has two independent piping systems, i.e., one that is common for the 35-, 15-, and 10-t furnaces, 1400 mm in diameter, and another one for the 6-t furnace only, 860 mm in diameter. The cooling of the gases occurs along the pipeline in the header and in the thin-walled cooler (the 35-, 15-, and 10-t furnaces). The gases exhausted from the 6-t furnace bypass the cooler, owing to which, among others, the effective cross section of cooler and its size can be smaller. Two fans are operated in the system, the third one kept as a backup.

The collection of dust from the gases exhausted from all the four furnaces is accomplished in a 14-chamber fabric filter operated under partial vacuum. Upon cleaning, the gases are released through the stack into the atmosphere. Each chamber accomodates 100 filter bags 140 mm in diameter. The overall filtration surface amounts to 1980 m². The filter unit is equipped with an automatic rapping mechanism separate for each chamber.

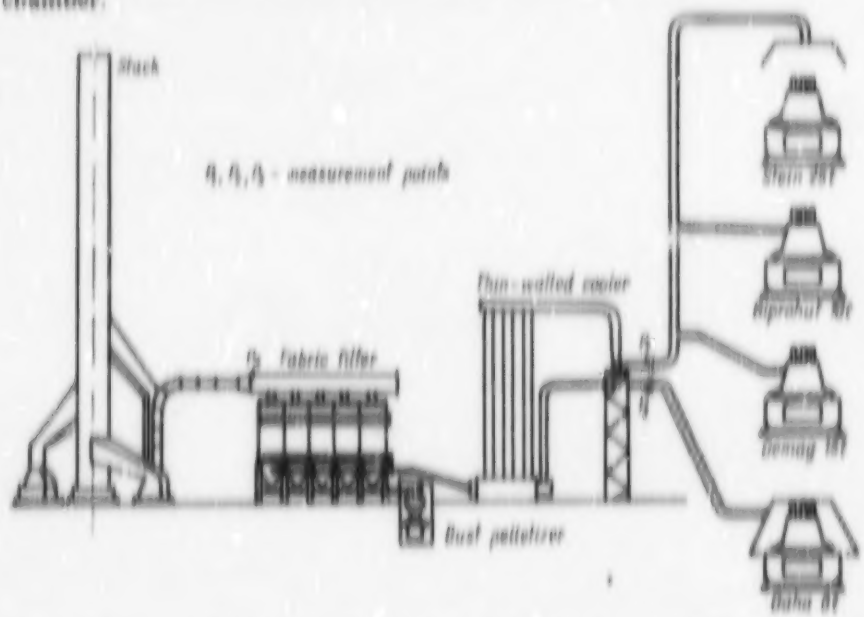

Fig. 1. Diagram of the dust control system for the electric arc furnaces at the Baildon Ironworks

The dust precipitated on the filter is fed by means of worm conveyors into an intermediate tank, and subsequently onto the pelletiser. In turn, the dust pellets are carried on by means of a skip feeder to a storage bin, from where they are transported with dump trucks to the dumps. Further plans contemplate utilization of the pelletized dust. A schematic diagram of the system is shown in Fig. 1.

Appraisal of the Performance of the System on the Basis of the Measurements and Observations Made

To evaluate the performance of the system, two measurement series were carried out. The first series was conducted two weeks after the system had been placed on stream, when only three furnaces (the 15-, 10-, and 6-t units) were served with the use of a merely one fan. The second measurement series was run two months later when the fourth, 25-t furnace was plugged into the network. In both the series dust concentration was measured at the following points:

— upstream of the fabric filter in the pipeline exhausting gases from the 25-, 15-, and 10-t furnaces,

— as above, but in the 6-t furnace exhaust line,

— downstream of the fabric filter in the common pipeline.

At the measurement points before the filter also gas flow rate was measured, and the analysis of the gas was performed.

To average the results, samples were taken for prolonged periods, i.e., from 0.5 to 5 hr, allowing to pass through the measurement filter 2 to 30 m³ (STP) gases. Individual results of the measurements of dust concentration and gas flow rates are shown in Figs. 2 to 5. As it can be seen,

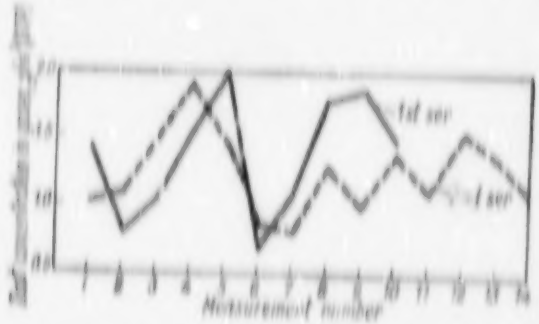

Fig. 2. Measurement results of dust concentration in the waste gases exhausted from the 25-, 15-, and 10-t furnaces upstream of the fabric filter; *1* and *2* denote measurement series.

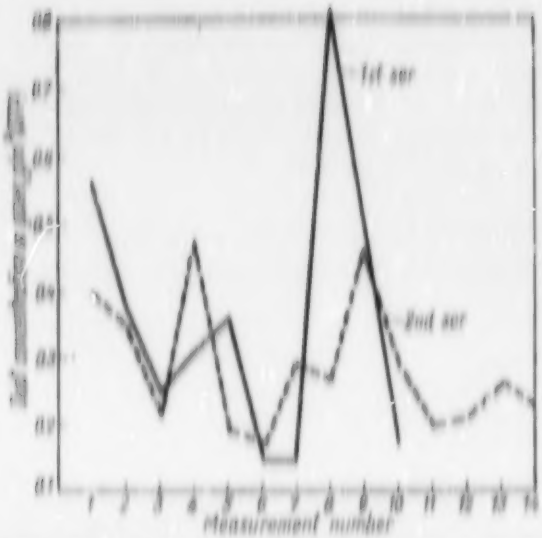

Fig. 3. Measurement results of dust concentration in the waste gases exhausted from the 6-t furnace upstream of the fabric filter; 1 and 2 denote measurement series.

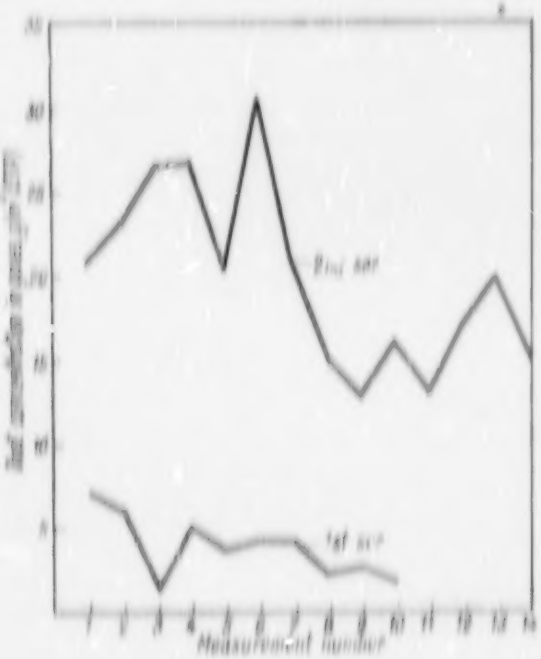

Fig. 4. Measurement results of dust concentration in the waste gases downstream of the fabric filter; 1 and 2 denote measurement series.

the dust concentration in the gases exhausted from the 16- and 10-t furnaces (series no. 1) ranged from 0.70 to 2.14 g/m³ (STP), in the series no. 2 being 0.79 to 1.89 g/m³ (STP). For the 6-t furnaces with the hooding system the corresponding values for series no. 1 and 2 were 0.15 to 0.81 and 0.16 to 0.46 g/m³ (STP), respectively. Downstream of the fabric filter dust concentration ranged from 1 to 7 mg/m³ (STP) (series no. 1) and 13 to 31 mg/m³ (STP) (series no. 2).

The gas flow rate in the exhaust pipeline for furnaces of capacity of 10, 16, and 25 t varied from 31,000 to 50,460 m³/hr (STP) in series no. 1 and from 55,247 to 75,860 m³/hr (STP) in series no. 2. In the 6-t furnace exhaust pipeline the gas flow rate varied from 31,465 to 36,090 m³/hr (STP), (series no. 1) and from 28,114 to 33,110 m³/hr (STP) (series no. 2).

The temperature of gas upstream of the filter varied from 40 to over 100°C, not exceeding, however, 104°C.

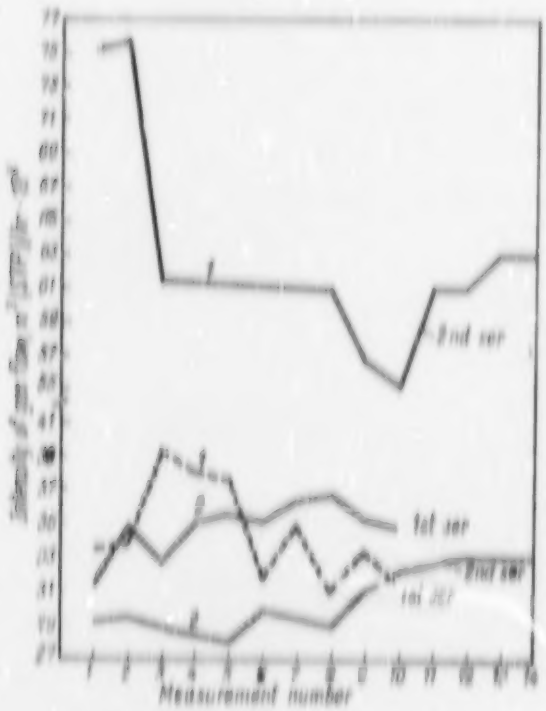

Fig. 5. Measurement results of the gas flow rate through the dust control system: *1* — on the exhaust pipeline of the 25-, 16-, and 10-t units; *2* — on the exhaust pipeline of the 6-t unit.

The average results from both experimental series are gathered in Table 1. From the comparison of these results it follows that the dust control system operating with three furnaces alone (i.e. the 15-, 10-, and

Table 1

Measurement Results

The quantity measured	Measurement unit	Measurement series no. 1	Measurement series no. 2
1	2	3	4
Gas flow rate			
— on the exhaust line from furnaces of Stein, Biprohut, and Demag types	m^3(STP)/hr	34,621	62,817
— on the exhaust line from the Daha type furnace	m^3(STP)/hr	34,901	30,621
— on the collective pipeline downstream of the fabric filter	m^3(STP)/hr	69,526	93,438
Average dust concentration			
— in the gas discharged from the furnaces of Stein, Biprohut, Demag types	g/m^3(STP)	1.4058	1.3301
— in the gas released from the Daha type furnace	g/m^3(STP)	0.1676	0.2887
— in the gas downstream of the fabric filter	g/m^3(STP)	0.0058	0.0199
The quantity of dust precipitated in the filter	kg/hr	61.5	88.0
	t/day	1.5	2.1
The quantity of dust not precipitated in the filter	kg/hr	0.3	1.9
Efficiency of fabric filter	%	99.6	97.9
Mean gas temperature			
— upstream of filter	°C	50	50
— downstream of filter	°C	41	41
Average negative pressure of gas			
— upstream of filter	N/m^2	2941	2744
	mm H_2O	300	280
— downstream of filter	N/m^2	4413	4218
	mm H_2O	450	430
Pressure drop across filter	N/m^2	1079 to 3451	
	mm H_2O	110 to 2250	
Degree of gas capture	%	80	average for all furnaces 80

6-t ones) proved adequate. With only one fan running the gas flow rate averaged 69,500 m^3/hr (STP). The capture of exhaust gases from the 15- and 10-t furnaces during steel melting and refining was complete. Merely when refining certain steel grades, where the exhaust draft had to be partially throttled, the gas capture was less efficient. The average degree of capture of gases from the three furnaces was estimated at 80%. The

efficiency of fabric filter was really high to amount to an average 99.8%.

When the 35-t furnace was plugged into the system the collection effect was reduced. Despite the fact that the other fan was put into operation, the average gas flow rate amounted to a mere 93,400 m³/hr (STP). A direct hooding of the 35-t furnace cannot ensure a higher capture than 50% during steel refining process. The average degree of capture for all the four furnaces was estimated at no more than 80%. The average collection efficiency of fabric filter in that period was 97.9%.

The amount of dust precipitated in fabric filter in the measuring series no. 1 amounted to 1.5 t/day, being 3.1 t/day in the series no. 2.

In both measurement series no shutdowns of the system took place on account of erroneous design, poor engineering or inadequate maintenance of the equipment. The system is provided with a third backup fan to be used in case of failure of either of the operating fans.

Conclusions

The following conclusions can be drawn as to the operation and performance of the dust control system on the basis of the measurements and observations made.

The system has substantially contributed to reduce the dust emission into the atmosphere from the steel-melting shop, although the problem is not conclusively solved as yet. Despite that 5.0 kg of dust per one ton of steel made is precipitated in the filter, the dust emission index is still 4 kg of dust per one ton of steel.

During operation of the system the following factors that bear a direct influence upon the optimum capture of gases from individual furnaces could be singled out, namely,

(a) opening of charge doors of furnace as seldom as possible during charging the furnaces and refining under white slag,

(b) periodical cleaning of the elbows of the gas exhaust line,

(c) maintaining tightness between the hearth and the furnace roof.

Further reduction of dust emission from the steel-melting shop could be possible upon application of a direct hooding on the 35-t furnace, which under the present conditions of the plant is hardly feasible.

It is known, however, that in an efficient dust control system only 85% of gases can be captured and cleaned, since the fourth roof opening must be occasionally taken out of service during performance of certain process operations, like refining under white slag. In such a case the final solution would be a two-stage dust control system, i.e., providing an extra

control system designed to control the fumes spreading around the shop with the help of hoods hanged over the furnaces. It is only such system that is deemed efficient in reducing the dust emission from the electric-furnace steel-melting shop.

Within the framework of planned modernisation of the plant the construction of new furnace unit is contemplated to replace the present steel shop. The new electric-furnace steel shop provides a two-stage dust control system. The existing system will be used as the first-stage control system upon necessary adaptation work.

Haczewski, J.

THE DUST CONTROL PROBLEMS IN CEMENT INDUSTRY

(Problemy odpylania w przemyśle cementowym)

The major sources of dust emission in cement industry are discussed along with the characteristics of the dust and gases emitted from such sources. The dust control methods in use are covered and the trends in the work on modernization of dust control systems and equipment are treated.

Cement industry in Poland is now one of the major sources of dust pollution of the atmosphere, whereas the development of this industry that proceeds at a fairly high rate poses a potential hazard to the natural environment. This is naturally due to the peculiar nature of the production of that industry, where large volume of comminuted material is handled to obtain the end product — cement, which is also dust.

The dusts emitted from the process equipment during the cement manufacturing process present a hazard to the environment near the pollution source because they occur in large quantities, and additionally they exhibit binding property, which results in damaged glass, fronts of buildings and, in the first place, in ravaged vegetation. It is worth noting that the majority of such dusts even upon precipitation in dust control equipment represent a troublesome, hard to utilise waste. If, on the other hand, disposed of on dumps, they spread around in the surroundings which makes the whole process of their precipitating useless. The dusts emitted from bagging machines and cement mills, apart from posing the environmental hazard, are a loss in the end product. For that reason the dust collection in cement industry is an involved and extensive problem to include hermetization of equipment, equipping ventilation hooding, and precipitation of the dusts from gas streams exhausted for ventilation purposes, as well as cleaning of the gases whose exhausting from the equipment is necessary for manufacturing reasons.

A rapid growth of building industry with the accompanying rise in

demand for cement entails a significant expansion of production in the existing plants and the construction of new ones that are usually complete import units. In both cases serious problems with dust collection arise. In the cement manufacturing process the main dust generation sources are such processes as clinker sintering, cement pulverising and bagging. The remaining processes, i.e., slag drying, crushing of raw material, drying and milling of material, homogenization of clinker cooling, and transport and storing of the stock, despite the fact that they also need dust control equipment, they are not so serious pollution sources on the contrary to the processes mentioned previously.

A separate problem is the emission of coal dust from the coal pulverization and drying systems. This is because with a few exceptions Polish cement plants use pulverized coal as fuel.

Clinker Sintering

The clinker sintering process is conducted in kilns fueled with pulverized coal, and occasionally with heating oil. The kilns used in Polish cement industry feature a wide diversity of types. The kilns differ in length and diameter, the way they are charged, the heat exchanger design and in the way hot clinker is cooled. Since all the factors mentioned, and also the kiln load and the design of dust chamber, critically affect the quantity and properties of the emissions discharged, every kiln should in general be treated individually, with the exception of kilns of the same design and operated in the same plant. An exact relation between the kiln design and the properties of the emissions discharged cannot virtually be determined, and merely some general correlations can be given. Moreover, it should be borne in mind that the clinker sintering process can be run either by the "wet" or "dry" technique. In the dry technique the kiln is fed with so-called stock flour of a minor moisture content, while in the wet technique it is sludge that is fed there. The majority of Polish cement plants operate after the wet technique and for this reason much attention is given to that process.

The Wet Technique

The exhaust gases emitted from the cement kilns operating by the wet technique are featured in the first place by a high moisture content, which amounts most frequently to about 300 g/m³ (STP) dry gas. The highest values of moisture content are usually encountered downstream of the kilns which are featured by a good heat recovery from the exhausts

and a low unit fuel consumption. The moisture content there attains occasionally as high as 800 g/m³ (STP). Conversely, downstream of the small-size kilns not provided with heat exchangers and featured with a high fuel consumption, for which the ratio of the quantity of the exhausts to the quantity of the clinker produced is high, the moisture content falls below 100 g/m³ (STP).

Similarly to the moisture content, the temperature of the gas downstream of the kilns depends upon the way the kiln is fueled and upon the heat recovery in the unit. The better the combustion process and the better the design of heat exchangers, the lower the temperatures of the exhausts discharged from the kiln. It is worth mentioning that heat recovery is a function of kiln load, and the overload of the kiln results in a temperature rise.

Downstream of the high-recovery kilns operated under rated conditions the exhaust temperatures amount to about 450°K whereas for low heat-recovery units the temperatures achieve 530°K and in extreme cases as high as 650°K.

Like the temperature and moisture content, also dust concentration in the exhausts varies over a considerable range. The main factors to affect the dust concentration in the exhausts are kiln design parameters, dust recycling back to the kiln, the kind and design of heat exchangers, dimensions of the dust chamber, and the kiln load. Such a considerable number of factors effecting the dust concentration in the exhausts result in that the quantity varies over a wide range. Specifically, for long kilns without concentrators and operated under rated loads, the dust concentration does not exceed 10 g/m³ (STP), whereas for medium-length kilns equipped with concentrators and small dust chambers the values attain a level above 100 g/m³ (STP).

Physicochemical properties of dusts downstream of the clinker kilns in the wet technique are likewise variable over a wide range. The grain size distribution of the dusts depends to a large extent upon the dust concentration. For the kilns where high dust concentrations occur the share of coarse grains is high and for particles of the equivalent diameter larger than 40 μm exceeds 40%, while at low concentrations the share of grains of equivalent diameters below 5 μm exceeds 30%. The grain size distribution of dusts exhausted from clinker kilns is shown in Fig. 1. The densities of the dusts in point vary from 2300 to 2900 kg/m³, their bulk densities from 550 to 940 kg/m³, whereas their angle of repose, from 38 to 40°. Resistivities of the dusts under ambient conditions are high and as a rule they exceed 10^{11} Ω·cm. These values are, however, much lower in a humid atmosphere of the exhaust gases.

The data specified above refer to a normal operation of the kilns and do not include the startup period or idle operation. These are exceptional situations when the characteristics of the exhaust gases downstream of the cement kilns substantially differ from the average values.

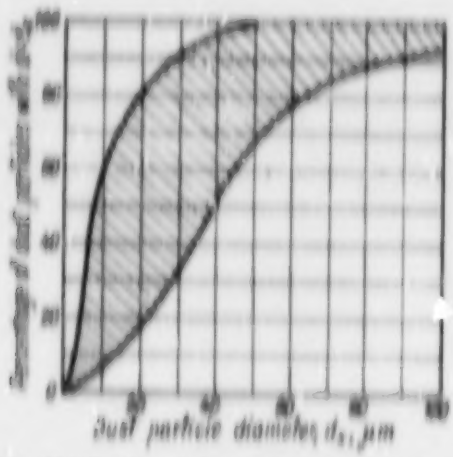

Fig. 1. Grain size distribution of the dusts exhausted from cement kilns

The cement clinker sintering kilns are equipped with dust settling chambers and electrostatic precipitators. The chambers themselves, or in the arrangement where the latter are followed by cyclones, are old-fashioned and do not ensure proper cleaning of the exhaust gases especially from fine particles. Both the devices and especially settling chambers, are useful, however, as precleaning stages. The major dust collection devices for clinker sintering kilns are electrostatic precipitators. Their principal advantages are that such gases can be handled that are hot and have a high dew points, with a high efficiency for arresting particles of low equivalent diameters.

Electrostatic precipitators may attain high operating efficiencies both for the dry and wet technique of clinker production on condition of a suitable matching to the specific problem at hand, and provided that the gas parameters at the inlet to the precipitator are appropriate. The commonly operated electrostatic precipitators ensure under optimal operating conditions a dust concentration in the cleaned gases from 300 to 400 mg/m³ (STP), and the latest units attain the value 100 to 300 mg/m³ (STP). These values are too high for the European standards which are 150 mg/m³ (STP) as the maximum allowable concentration. Meanwhile a number of electrostatic precipitators work much worse, and the dust concentrations

in the cleaned gases amount to 0.7 to 1 and more g/m³ (STP). The reasons for this may be sought among such factors as the low designed efficiency, overload of the precipitators with gases due to a forced operation of the kilns, rise in temperature of the gases above the values admissible for a given design, as well as deliberate lowering of the voltage for fear of explosions.

Under such conditions, especially for the wet technique, the electrostatic precipitators preceded by settling chambers appear to be an optimum arrangement, provided that the devices are of an advanced design. Furthermore, work should be conducted on stationary conditions of the kiln heating process to prevent explosion hazard, which is always imminent during the operation of electrostatic precipitators.

Bag filters are the other alternative, as their unquestionable advantage is the lack of sparkovers associated with the electric precipitators, which, in the presence of CO in the gases that appears when the kiln is improperly fueled, may initiate explosion. A drawback of bag filter is that the fabric may be burnt at the instantaneous temperature rise or it may be clogged when the temperature of gases falls to too low a level. Thus both the bag filters and electrostatic precipitators require a stationary operation of the kilns.

The Dry Technique

The process of clinker sintering by the dry method is also run in kilns. The significant difference in the properties of the gases released from the kilns operated after the dry or wet techniques consists in that in the dry technique the humidity of gases is much lower as compared with the wet technique. The reason for that is, of course, a low moisture content in the charge. However, the exhausts from kilns in the dry technique are of a much higher temperatures than those from the wet process. In this connection, the exhaust gases are not vented directly to the dust collection equipment but are utilized to heat the stock mills or else to dry slag. In the latter case the exhausts acquire some humidity. The use of the exhausts from the drier furnaces, however, offers some problems in operation, as the kiln and the devices which utilize the heat are to be always run simultaneously. This is possible for the devices featured by an appreciable reliability coupled with their adequate automatic control.

For the treatment of the exhaust gases from the wet process exclusively electrostatic precipitators are used in Poland. However, the gases have to be humidified before they enter the dust control unit. Whenever in the process (driers) the gases are insufficiently or not at all humidified, humidifying and cooling towers should be resorted to, which ensure a con-

steam temperature and humidity of the gases before they enter the precipitators. Without the towers serious disturbances arise in the operation of precipitators in case of break in operation of the drier or mill, or even the precipitators may be damaged on account of the excessive temperature rise. In other countries, in the United States in particular, fabric filters are increasingly coming into a widespread use in cleaning the gases from kilns in the dry process. This is primarily due to the very rigorous standards provided for the atmospheric pollutants. The fabric filters, being at the same time less expensive than electrostatic precipitators, are more efficient. Under our conditions, however, in view of the notable problems with filtering fabrics, replacement of the electrostatic precipitators with fabric filters is at present unsound. This, on the other hand, does not imply, of course, that research in this field should not be conducted.

Cement Pulverizing Operation

The cement pulverizing operation is carried out in ball mills charged with suitable materials such as clinker and gypsum, and occasionally with slag and fly ashes. In the milling operation, on account of vigorous friction, considerable heat evolves. The heat must be taken off from the mills to prevent overheating of the cement. This is accomplished mainly by passing the air through the mills, i.e., by exhausting the air from the free space in the units. Other measures include spraying the mills with water and feeding water into the mills. The parameters of the dust-laden gas exhausted from the mills depend upon the mill design, exhaustion rate, the kind of materials used and their moisture content.

The moisture content in the air exhausted from the mills is variable. It may be equal to 30 g/m³ (STP) for dry materials and vigorous exhaustion or it may exceed 500 g/m³ (STP) when water is added, or for a moist material and low exhaustion. For the very same reasons considerable variations in the moisture content were observed in the gases exhausted from the same mills. The variations are significiant and exceed 150 g/m³ (STP). The main reason for such variations is a variable moisture content in the materials charged into the mills, mainly in gypsum. Often, however, clinker or slag happen to be moist. The air temperature in the stream leaving the mills is usually 380 to 400°K.

The dust concentrations in the air downstream of the cement mills are also different for individual mills and variable for the same units from about 25 to 1000 g/m³ (STP). Very high dust concentration occurs mainly for the kilns designed for lower capacities but subsequently operated under forced conditions by means of increased rate of the air ex-

hausted. Similarly, an increased percentage of fly ash in the mill charge results in a considerable rise in the dust formation. The average dust concentrations in the air stream downstream of the kilns vary, however, from 100 to 400 g/m³ (STP).

The grain size distribution of the dusts exhausted from the cement mills is similar to that in the case of the kilns, which is illustrated in Fig. 2. Like for the kilns also for the mills, higher dust concentrations are accompanied by increased percentage of coarse particles, and at lower

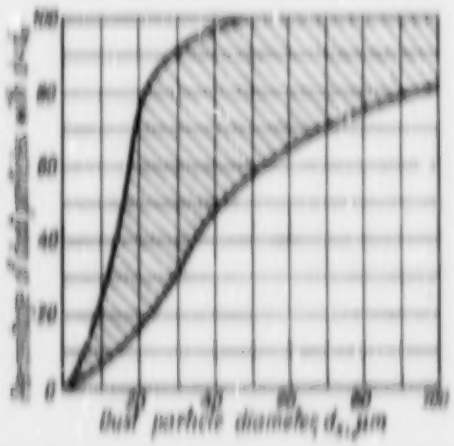

Fig. 5. Grain size distribution of the dusts exhausted from cement mills

dust concentrations accordingly fine fractions prevail. The dusts exhausted from cement mills feature a specific gravity of 2700 to 3100 kg/m³, bulk density of 750 to 1050 kg/m³, whereas the density of shaken dust varies from 100 to 1400 kg/m³. The resistivity of dusts from the cement mills is various and depends upon the materials used, grain size distribution and air humidity. At 380°K and the ambient humidity the resistivity of the majority of such dusts exceeds 10^{12} Ω·cm.

The air exhausted from cement mills is cleaned in bag filters or electrostatic precipitators. Such collectors are often preceded by cyclone collectors which serve the purpose of preliminary collection stages. Bag filters are used for the mills of low capacity ranging below 30 t/hr. The filters of the latter type not infrequently perform unsatisfactorily. There occurs quite often a condensation with the resultant rise in the resistance to air flow and thus a reduced exhausting rate from the mill, and the filters easily lose tightness. The situation is aggravated by the fact that the units are usually of an old-fashioned type. Bag filters have been used

also in singular cases in new designs downstream of the high-capacity (75 t/hr) mills. Condensation was not observed in those new units; nevertheless the efficiency of operation is still far from satisfactory.

With medium-capacity mills vertical electrostatic precipitators are now used coupled with cyclone collectors that precede such units. Horizontal electrostatic precipitators may also be employed. Efficiency of such units varies, but it must be admitted that, essentially in the plants where they are properly maintained, they perform satisfactorily attaining efficiency above 99%, with the ultimate dust concentration in the discharged gas ranging 100 to 500 mg/m³ (STP). In view of the above it is commonly believed that the most suitable dust control system for cement mills are electrostatic precipitators of advanced design. For low-capacity units, where the quantity of exhausted air is small, fabric filters must be used. However, considerable moisture that not infrequently appears in the exhausted air will always bring about troubles in their operation. Some attempts are made here to overcome these difficulties by heating the gases with electric heaters before they enter the precipitators, by mixing the gases with the air previously heated in a steam heater, or employing other similar solutions depending upon the problem at hand and available measures. These are, however, merely half-measures that are usually unreliable. In this connection it appears that less expensive and more efficient is the drying of materials containing moisture in appreciable amounts before they are fed to the mills.

Cement Bagging

Pulverised cement is fed from the mills to storage tanks, from which it is loaded in bulk onto trucks or railroad cars, or else conveyed to bagging machines. Compressed-air bagging machines are designed to pack cement into bags. Cement industry employs two kinds of bagging machines: the old-type, immobile, usually three-valve types and new models, mobile, for 13 or 14 valves. With the old-type immobile machines a number of exhaust lines is used one of which leads from the machine chamber. All the lines are attached to a common dust collector. Dust concentration in the exhaust lines amounts from a few to fifty or more g/m³ (STP), depending upon the positioning of the exhaust point. In the machine chamber the dust concentration usually exceeds 100 g/m³ (STP). The new-type bagging machines are essentially equipped with one exhaust line atop of the chamber. The dust concentration in that line varies from 10 to 40 g/m³ (STP). Instantaneous dust concentrations in those lines may be much higher in case a bag breaks or one of the vents fails.

The dusts exhausted from bagging machines do not essentially differ

in grain size distribution from those exhausted from cement mills or kilns, although they lack in the finest and coarsest particles (Fig. 3.).

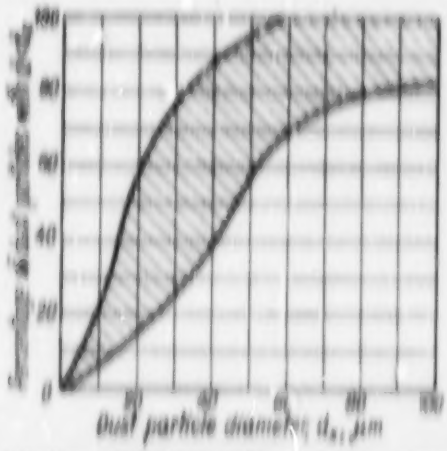

Fig. 3. Grain size distribution of the dusts exhausted from cement bagging machines.

For the cleaning of the air exhausted from cement bagging machines today only bag filters are used. This is reasonable, as it is dry air coming from the exhaust systems that is cleaned. The problems with the service of such filters stem from the poor quality of the fabric used as well as from the faulty design of the filters. The filters currently used for the bagging machines are usually in poor condition, and the ultimate dust concentration in the air released from the machines infrequently falls below 300 mg/m³ (STP), being typically even above 1 g/m³ (STP).

Trends in the Work on the Improvement of Dust Collection in Cement Industry

The major two trends in the work on modernisation of dust control systems for cement industry should be concerned with the basic technical relations: suitable changes in the process parameters to permit a correct operation of dust collection equipment, and a continued modernization of the collectors themselves.

As concerns the changes in the process parameters, one of the most essential problems is stationary operation of the kilns so as to avoid considerable variations in the gas parameters at their exit. To achieve this, in the first place the combustion and charging operations should be automated.

With small cement mills and especially those designed to handle slag and fly ash, attempts should aim at making the drying operation of these materials prior to the milling become a common practice to permit normal operation of fabric filters.

As concerns modernization of the dust collection design, attention should be paid to the units downstream of the kilns with a full use of the license purchased from LURGI company. Efforts should be made to implement only one type of electrostatic precipitator in the entire cement industry, as in view of a considerable diversity of the types used now serious problems arise with spare parts and overhauls.

Many of the fabric filters in use today should be replaced by more advanced equipment. Special emphasis should be placed on the implementation of pulse filters and nonwoven filter fabrics. The pulse filters, in view of the lack of moving parts and a very simple automatic control, feature a considerable operational reliability. The nonwoven filter fabrics in turn permit operation of dust collectors at lower resistance to gas flow and at higher filtration rates than are possible with woven fabrics, and with higher collection efficiencies than with the latter.

The work on the design and implementation of pulse filters has been completed in this country, and the filters of this type can be used for the exhaust systems of cement bagging machines with the use of imported nonwoven filter fabrics.

The research on the implementation of domestic filter nonwovens is now in progress, and the first desirable results have already been gained.

Wasilewska, J.

THE INFLUENCE OF SOME METEOROLOGICAL PARAMETERS ON THE SPATIAL DISTRIBUTION OF POLLUTANTS IN THE ATMOSPHERE

(Wpływ niektórych parametrów meteorologicznych na rozkład przestrzenny zanieczyszczeń w atmosferze)

The influence of vertical equilibrium of the atmosphere on the pollution of surface air layers is discussed. For a specific point emission source calculations were made for the SO_2 concentration distribution in the surface layer under conditions of three basic types of the atmospheric equilibrium, i.e., the stable, labile and indifferent ones.

The problem of measurement of atmospheric pollution is a complex and troublesome task in view of a remarkable variability of the space-time field of emissions. The state of knowledge in this province, both experimentally and theoretically, is far from being entirely satisfactory.

Generally the measurements of atmospheric emissions are considered in three very distinct stages, namely:

- at the emission stage,
- at the dispersion stage (GLC),
- at the sedimentation or settling-down stage.

A fundamental quantity characteristic of the condition of pollution of the atmosphere is the emission concentration expressed as a ratio of the weight or the volume of the contaminant to the volume or, less frequently, the weight of air. There are permissible standards that regulate the content of individual atmospheric contaminants, referred to as maximum allowable concentrations or better, threshold limit values.

This article will cover the variations in the emission concentrations in the atmospheric air in the vicinity of a point emission source and downwind of the source under conditions of the fundamental types of atmospheric equilibrium, namely:

- stable equilibrium,
- labile equilibrium,
- indifferent equilibrium.

Vertical Equilibrium of the Atmosphere

The vertical exchange of air proceeds as a result of convectional motions of a considerably diverse extension. As a matter of common knowledge, air is a poor heat conductor, and for this reason the vertical motions in the atmosphere are essentially accompanied by adiabatic processes, during which the heat content of the air changes at the expense of the processes associated with the change in the atmospheric pressure.

For that reason on the assumption of minor vertical transport of an air parcel, it can roughly be admitted that the ratio of the temperature of the ambient air and of the air parcel moved equals unity, and the formula for the vertical adiabatic temperature gradient can be derived in terms of the barometric and the adiabatic equations, in the form

$$dT/d_z = g/C_p = \Gamma_1 \qquad (1)$$

where

dT — a quantity that determines the change in temperature of the air parcel during its displacement in vertical direction by a value d_z;

g — the acceleration of gravity;

C_p — specific heat under constant pressure.

The vertical temperature gradient of the air, Γ_1, expresses a ratio of an infinitely small increase in temperature of the air parcel, dT, to an infinitely small displacement of the parcel in vertical direction by d_z.

By substituting into the formula for the adiabatic temperature gradient (1) the values: $g = 9.81$ m sec^{-1} and $C_p = 1.00 \times 10^3$ kJ (kg K), one obtains $\Gamma_1 = 0.98$ K/100 m of altitude or, approximately, 1 K/100 m.

The vertical adiabatic temperature gradient therefore amounts to 1°C/100 m of altitude. In other words, on ascending vertically the air temperature drops by one degree centigrade per every 100 m, while on descending its temperature decreases by one degree centigrade with every 100 m.

From the conditions of adiabatic transition it follows that if the atmosphere actually had the adiabatic temperature gradient, the air density would be the same at every altitude. Under similar conditions no buoyancy forces would act on the air parcel displaced from the initial position up or downward to move it further on. Thus the equilibrium of such an air parcel would be an indifferent one.

Under practical conditions, however, there is a natural heat exchange between the earth and its ambient air, and for that reason the temperature gradient may considerably differ from the adiabatic gradient and depending on the existing atmospheric conditions, it may assume lower or higher

values than 1°C/100 m of altitude, i.e., it may be lower or higher than the adiabatic gradient. Thus, the actual gradient Γ_1:

$$\Gamma_1 \leq \Gamma_{1'} \leq \Gamma_2$$

In case $\Gamma_{1'} > \Gamma_2$, the air parcel disturbed from its original position and displaced upward will always have a higher temperature compared with its ambient air and a lower specific gravity than the latter. In this connection it will move upward. Conversely, for an air parcel displaced downward, its temperature will be lower compared with the ambient air, and the parcel will be falling down. In view of the above reasoning the air parcel is at a labile equilibrium condition [3].

If $\Gamma_{1'} < \Gamma_2$, we have a stable equilibrium. The air parcel disturbed from its original position up or downward is always acted upon by forces that try to restore it to its original position.

In case the vertical temperature gradient assumes negative values or, in other words, the upper-air layers are of a higher temperature than the surface layers, the phenomenon is referred to as temperature inversion [3].

Dispersion of emissions in the atmosphere depends, among other factors, upon the temperature gradient, i.e., upon the nature of the vertical equilibrium in the atmosphere. As the result of the effect of the vertical temperature gradient, the emission plume released from the source may assume various forms, and thus the distribution of emission concentrations may vary over a fairly considerable range.

The Method of Calculations

The scope and method of the analysis of the nuisance for the environment caused by the manufacturing plants considered, as well as forecasting of the emission problems for designed plants, depend upon the kind of emission source, its site, and the way in which the emissions are discharged into the atmosphere.

The calculative models now in use are primarily based on the point emission sources. The point emission sources are essential for the forecasting of emission conditions, as the introducing of linear or area source fails to alter the major algorithm of the calculation procedure, and merely associates with the assumption of simplified formulas. In this connection the example given below is concerned with a point emission source situated at a definite height and featured by stationary emission. The data:

- geometrical height of the stack, $h = 60$ m;
- i.d. of the stack exit, $d = 3$ m;
- emission rate of sulfur dioxide, $E = 46$ kg/hr;

— volume of the gases released, $V = 70 \times 10^3$ m³/hr, (STP);

— the temperature of the gases emitted, $t_1 = 140°C$;

— the ambient temperature at a height of 1 m above the ground, $t_0 = 0°C$;

— specific heat of the emitted gases, $C_p = 0.338$ kcal/m³ deg. (STP).

Calculations of the dispersion of SO_2 were carried out downwind of the source in the surface air layer 1 km away from the source under three kinds of atmospheric equilibrium conditions. Windspeed measured at a height of $E_0 = 10$ m above the ground was $u_0 = 5.4$ m/sec.

The SO_2 concentrations were calculated at points distant from one another by 500 m using the calculative model due to Pasquille [4], [5] and the atmospheric diffusion coefficients assumed after Malet [6]. The calculations were made on the assumption that SO_2 is not converted into any other chemical compound under the effect of atmospheric conditions, and that the temperature inversion is not involved in the layer where emissions are spreading. The Pasquille model for calculations on the above assumptions has the following form

$$S_{x,y,z,0-H} = \frac{E}{\pi\sigma_y\sigma_z u_{0-H}(E_0 - H)} \exp\left(-\frac{H^2}{2\sigma_z^2}\right) \qquad (3)$$

where

E — the 20-min concentration of SO_2 at a point distant from the emission source by x (x-axis coincides with the wind direction), mg/m³;

E — the emission rate for SO_2, mg/sec;

σ_y, σ_z — the atmospheric diffusion coefficients along the y- and z-axes, respectively, m;

u_{0-H} — the average windspeed at a level from E_0 to H, m/sec;

H — effective altitude of the emission source, m.

The atmospheric diffusion coefficients for particular equilibrium conditions appearing in the Pasquille formulas represent standard deviations of the normal distribution of the pollutant concentration in the plane, and have the dimension of length, as they depend upon the distance x of the measurement point from the source.

For example, the values of the diffusion coefficients $\sigma_y = 80$ m and $\sigma_z = 25$ m mean that the cross section of the emission plume with a vertical plane y, z is of a shape of an ellipse of the axes $2\sigma_y = 160$ m and $2\sigma_z = 50$ m (Fig. 1).

Formulas for the calculation of the turbulent diffusion have the following form

$$\sigma_y = Ax^n \qquad (3)$$

$$\sigma_z = Bx^n \qquad (4)$$

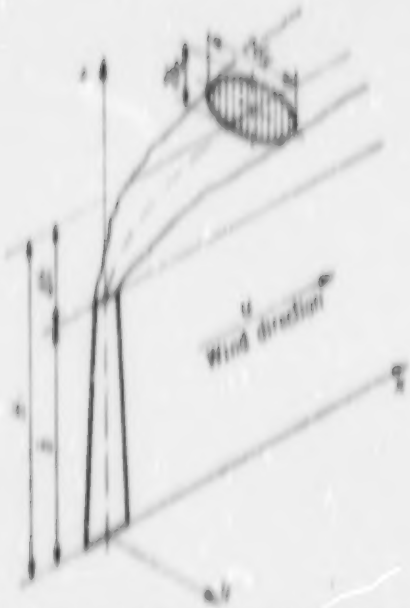

Fig. 1. The model of a point emission source with the cross section of the emission plume marked with a vertical plane y, z

where A, a, B, b are constant values for a given equilibrium type after Maist, and are as follows

	A	a	B	b
— stable equilibrium	0.195	0.798	0.311	0.711
— indifferent equilibrium	0.347	0.798	0.580	0.711
— labile equilibrium	0.690	0.798	0.730	0.711

The height of the apparent position of the emission source, H, was calculated from relation

$$H = h_s + \Delta h \tag{5}$$

where

h_s — the geometrical height of stack, m;

Δh — the overall superelevation of the emission plume above the geometrical height of stack, m.

Overall superelevation was calculated from the Holland formula of the following form

$$\Delta h = h(1.5 \cdot V_s d + 4.08 \cdot 10^{-4} Q_c) \frac{1}{u_s} \tag{6}$$

where

k — a coefficient dependent upon the atmospheric equilibrium type; for stable equilibrium $k = 0.85$, for indifferent one, $k = 1$, and for labile type, $k = 1.15$;

V_s — the velocity of gases at the stack outlet, m/sec;

d — the stack internal diameter, m;

Q_c — the amount of heat released by the stack, cal/sec;

u_h — the windspeed at the stack geometrical height, m/sec.

Because of the vertical profile of the windspeed distribution (i.e., windspeed varies with the height), the windspeed distribution at the stack

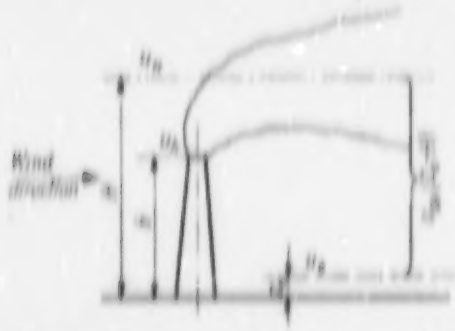

Fig. 9. Windspeed distribution at the level of geometrical stack height with average windspeed

geometrical height u_h and the average windspeed at levels from $Z = Z_0$ and $Z = H$ (Fig. 9) was found from the Sutton formulas

$$u_h = u_1 \left(\frac{h_1}{Z_0} \right)^{1/n} \tag{7}$$

$$u_{h+(H-h)} = \frac{1}{n} u_1 \left(\frac{H}{Z_0} \right)^{1/n} \tag{8}$$

where

n — the meteorological exponent dependent upon windspeed u_1 [7] (to be found from the tables), the remaining symbols as in formulas (3) and (5).

Values of the atmospheric diffusion coefficients for particular atmospheric equilibrium types are listed in Table 1.

The overall superelevation of the emission plume over the geometrical height of stack at the windspeed calculated using the Sutton formula at

a geometrical height of stack w_0 = 4.4 m/sec for particular atmospheric equilibrium types is as follows:

— for stable equilibrium, Δh = 13 m;
— for indifferent equilibrium, Δh = 15 m;
— for labile equilibrium, Δh = 17 m.

The average windspeed at a level $Z = Z_0$ to $Z = H$ for particular equilibrium types, on the assumption of an average turbulence determined by coefficient n = 0.25 is the following:

— for stable equilibrium w_{sr} = 3.94 m/sec,
— for indifferent equilibrium, w_{sr} = 3.97 m/sec,
— for labile equilibrium, w_{sr} = 3.98 m/sec.

Table 1

Values of the Atmospheric Diffusion Coefficients for Particular Equilibrium Conditions of the Atmosphere

Equilibrium type	Values of the coefficients for particular distances									
	x_1 = 200 m		x_2 = 400 m		x_3 = 600 m		x_4 = 800 m		x_5 = 1000 m	
	σ_z	σ_y	σ_z	σ_y	σ_z	σ_y	σ_z	σ_y	σ_z	σ_y
Stable	17.9	11.4	33.9	23.0	37.4	39.5	39.6	33.1	47.8	43.0
Indifferent	31.8	23.4	40.8	36.8	51.6	48.8	70.7	59.6	84.0	70.1
Labile	63.9	41.0	80.1	67.3	114.0	89.6	140.0	109.0	168.0	128.0

In view of the fact that average windspeed values are close to one another for different equilibrium types, a value of w_{sr} = 4 m/sec was taken for the calculation of SO_2 concentrations.

Table 2

The SO_2 Emission Concentration Distribution at Particular Measurement Points

Equilibrium type	The 30 min SO_2 concentration, mg/m³ air, at individual points distant from the source				
	x_1 = 200 m	x_2 = 400 m	x_3 = 600 m	x_4 = 800 m	x_5 = 1000 m
Stable	traces	0.0070	0.0046	0.0043	0.1013
Indifferent	0.0043	0.0715	0.0066	0.0051	0.0516
Labile	0.0589	0.0044	0.0031	0.0450	0.0142

Distribution of emission concentrations in individual points over the area considered for the three basic types of atmospheric equilibrium types is gathered in Table 3.

Discussion of the Results

The SO_2 concentration distribution in the ground air layer at a distance of 1000 m from the emission source is plotted in Fig. 3. As follows from the graph, the distribution is to a large extent controlled by the ver-

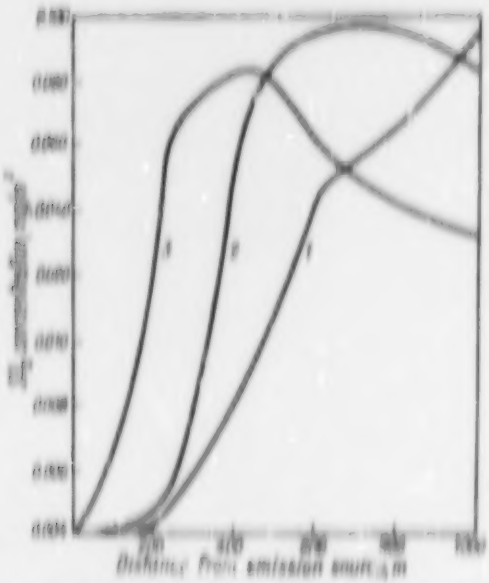

Fig. 3. Distribution of 20-min SO_2 concentrations in the ground air for a point emission source under various types of vertical atmospheric equilibria: *1* — stable; *2* — indifferent; *3* — labile.

tical atmospheric equilibrium. Near the source the highest emission concentrations will be observed under labile equilibrium of the atmosphere. For our example, at a distance of 400 m from the source the SO_2 concentration equals ca. 0.084 mg/m³, for indifferent equilibrium, ca. 0.073 mg/m³, and for stable equilibrium it was nearly one tenth as high (in relation to the remaining ones) and amounted to more 0.008 mg/m³ air.

On the other hand, 1000 m away from the emission source the SO_2 concentration distribution in the ground air layer assumes a different character. The highest concentrations occur under the stable equilibrium conditions, and the lowest ones under the labile equilibrium conditions.

Under stable equilibrium the SO_2 concentrations noted are about three times as high as those observed for labile equilibrium in the atmosphere. For that reason, in the analysis of the nuisance problem offered

by the operative manufacturing plants, or in forecasting the nuisance level of new designed plants, the most unfavorable meteorological conditions should be taken into account, for which the highest emission concentrations will occur.

The theoretically highest emission concentrations in the atmosphere will occur at a critical windspeed for a given emission source.

The critical windspeed for a specific emission source can be calculated from the simplified formula

$$u_{cr} = \frac{\Phi}{h}\left(\frac{Z_0}{h}\right)^{1/3}$$

where Φ stands for the parameter characteristic of the stack, this is the numerator of the formula for calculation of the emission plume superelevation above the geometrical stack height.

It follows from the example considered that the spell of stable vertical equilibrium in the atmosphere will be the most unfavorable for the specified emission source and the emission parameters at the given windspeeds. As far as 1000 m away from the source considerable SO$_2$ concentrations will still be observed in the surface air layer (0.1 mg/m^3 air). For the stable type of vertical equilibrium we also see the lowest superelevation of emission plume over the geometrical stack height.

Under labile equilibrium conditions there are trends for fairly high gaseous emission concentrations in the surface air near the emission source (Fig. 3).

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ANALYSIS OF THE DUST COLLECTION PROCESS ON GRANULAR BEDS

(Analiza procesu odpylania na warstwach ziarnistych)

The dust collection process and resistance to gas flow on granular beds are analysed theoretically and experimentally. From the study made equations were derived for collection efficiency and resistance to flow for three granular beds. The equations are of use in designing granular-bed collection devices.

The question of cleaning of aggressive or high-temperature off gases by dry methods without a necessity to reduce their temperature is of paramount significance of a vast number of manufacturing processes in chemistry, metallurgy, power industry and related industries. The cooling of high-temperature dust-laden gases is an expensive operation considering both capital and running costs, particularly if utilisation is not feasible. In this connection, the design of dust control systems in which the previous cooling of the off gases could be avoided has been the target of continued effort for many years. One of the more successful designs is that in which porous granular beds are employed as the dust-arresting element.

Model of the Process of Dust Collection on a Granular Bed

The flow of an aerosol through a granular bed, which represents a characteristic filtration structure, involves its division into streamlines that flow around a bed element. During the gas flow around the bed element, the dust particles present in the streamline are subjected to some forces resulting from the energy of the moving dust particle and the effect

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of forces characteristic of gravitational and electrical fields. The collection efficiency is controlled by the resultant force responsible for a permanent contact of a dust particle with the bed element.

Depending on the specific parameters of the granular bed and aerosol involved, as well as on the flow rate and the way the gas stream is fed, the collection process follows one or several mechanisms at the same time. Thus the overall collection efficiency is a function

$$\eta = f(k_b, k_z, k_g, k_d, k_e, k_s) \qquad (1)$$

where overall collection efficiency depends upon the effect of the parameters responsible for the respective collection mechanisms, viz., k_b inertial, k_z impingement, k_g gravitational, k_d diffusive, k_e electrical mechanism, and that due to division of the aerosol stream k_s [2], [3].

To determine the physical quantities that control the formulation of parameters k the flow around a spherical bed element by an aerosol stream is usually considered (Fig. 1). Those dust particles the paths of which are still tangential to the surface of the sphere become arrested. Particles *1* and *2* are arrested on the filter owing to inertial and impingement mechanisms. Particles deflected from the path tangential to the sphere surface may show a tendency to glide over the surface and they become permanently settled down only on the rear sphere surface, which corresponds to the zone referred to as wake [4].

Fig. 1. Streamlines and paths of dust particles with the zones of permanent settling of dust marked.

Dust particles precipitated due to electrical mechanism (particle *3* in Fig. 1) and diffusive mechanism also exhibit a tendency to a surface glide which, however, is to a large extent conditioned by the properties of the surface of the element around which the gas flows.

On the assumption of a selective contribution of individual dust collection mechanisms during the flow around a single spherical element, differential equations have been derived for the dust motion and collection efficiency equations have been formulated for individual mechanisms [1].

Theoretical analysis made allowed to determine theoretical collection efficiency for the flow around a single spherical element by a polydisperse aerosol stream in terms of the fundamental parameters, in the following form

$$\eta_t = f(d_t, d_p, \varrho_t, \varrho_p, \eta, D, w_0, g) \tag{2}$$

To obtain a full characteristic of a dust collection device, relationship between the dust collection efficiency of a single bed element described by fundamental physical parameters (2) and efficiency of the granular bed should be found.

Mass collection rate of dust and aerosol stream can be determined for a unit bed by equation

$$d\dot{m} = (-w_0 F)dc \text{ kg/sec} \tag{3}$$

or considering collection efficiency of a single element

$$d\dot{m} = \eta_t f_t n w c \text{ kg/sec} \tag{4}$$

Taking into account that the number of the bed elements of any shape that corresponds to the bed height of dh, is

$$n = \frac{(1-\varepsilon)\psi F \cdot dh}{\frac{\pi d_t^3}{6}}$$

and the velocity of aerosol stream in the bed

$$w = w_0/\varepsilon \text{ m/sec}$$

and the cross section of a dust particle

$$f_t = \pi d_t^2/4 \text{ m}^2$$

upon comparing equations (3) and (4) one obtains

$$-\int_{c_0}^{c} \frac{dc}{c} = \eta_t \frac{1.5(1-\varepsilon)\psi}{\varepsilon \cdot d_t} \int_0^H dh$$

Solution of the above equation affords the following relation describing collection efficiency of the granular bed

$$\eta = 1 - \exp\left[-\frac{1.5(1-\varepsilon)\psi \cdot H \cdot \eta_t}{\varepsilon \cdot d_t} \right] \tag{5}$$

Since, however, as it results from comparison of the mass transport equation

$$dk = (kF)dc; \text{ kg/sec}$$

and the material balance equation for the dust control process

$$dk = (\eta_i F w_0)dc; \text{ kg/sec}$$

theoretical collection efficiency of a single element of the bed equals

$$\eta_i = k/w_0 \tag{6}$$

thus the equation for collection efficiency of the granular bed has the form

$$\eta = 1 - \exp\left[- \frac{1.5(1-\varepsilon)\psi \cdot H \cdot k}{\varepsilon \cdot d_0 \cdot w_0} \right] \tag{7}$$

Considering equations (3), and (6) the collection rate coefficient may be written in the following functional form

$$k = f(d_1, d_0, \varrho_0, \varrho_p, \eta, D, w_0, g) \tag{8}$$

Upon application of the dimensional analysis by the Rayleigh exponent method the following criterion equation was derived for the dust collection process on a single bed element

$$\mathrm{Mo}^1 = C(\mathrm{Re})^a(\mathrm{Stk})^b(\mathrm{Fr})^c(\mathrm{Pe}^1)^f \tag{9}$$

where

$\mathrm{Mo}^1 = k/w_0$ — the Margulis number characteristic of the similarity of the phenomena that occur during the aerosol flow around a spherical element.

Determination of the constant and regression coefficients of the criterion equation required comprehensive research to be done. Investigation was performed on a semicommercial plant (Fig. 2.) for the dust collection from aerosol on a granular bed.

Three kinds of beds were examined, and specifically beds of polystyrene, gravel, and quich coke. The aerosol flow rate was varied over a range of $w_0 = 0.1$ to 1.0 m/sec and three measurements of collection efficiency were made for each rate value. Four bed heights were used in the measurements, viz.: $H = 50$, 100, 150, and 200 mm. All the measurements were carried out for the initial dust concentration $c_0 = 1.0$, 5.0, and 10.0 g/m³ for the same dust, which was technical talc, of the particle equivalent diameter of $d_1 = 17.88 \times 10^{-6}$ m and a density of $\varrho_p = 2.6 \times 10^3$ kg/m³. The whole setup was operated under negative pressure, and the flow was forced by means of three SWS 01 vacuum cleaners, whereas the flow rate

Fig. 4. A photograph of the experimental setup.

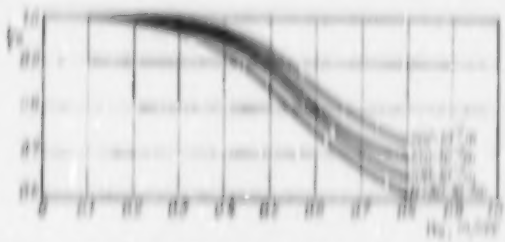

Fig. 5. Collection efficiency on the quick coke beds.

was measured with flowmeters. Aerosol concentration was adjusted by means of a calibrated dust generator, while the final concentration was determined with a probe using a filter insert.

Results of the Study on Collection Efficiency

At the preliminary stage of the study, properties characteristic of the granular beds examined were determined. Results of the determinations are collected in the table.

It was found experimentally that in the range studied the initial dust concentration in the aerosol has no effect on collection efficiency. Shown in Fig. 5 is the plot of collection efficiency on quick coke bed for

various bed heights H. Each point of the curve was determined as an average of nine measurements. For a granular bed that consists of a set of bed elements a number of effects come into play such as possible interaction of the streamlines, collisions of dust particles followed by their agglomeration. It is also possible for the granules to be shielded by one

Table

Characteristic Properties of the Granular Beds Studied

Bed	$d_c \cdot 10^3$, m	ε, m^2/m^3	γ
Polystyrene	2.25	0.179	1.464
Gravel	4.37	0.175	0.887
Quick coke	4.67	0.613	0.599

another due to their contacting. These effects are responsible for the discrepancy in collection efficiency of a single bed element and that of the set of elements which constitutes the filtration bed. Thus the equation for collection efficiency of the bed (7) upon using equation (9) was written in the form

$$\eta = 1 - \exp[-P(\mathrm{Mn}^2)] \qquad (10)$$

where

P — a parameter characteristic of the bed, defined thus

$$P = \frac{1.5(1-\varepsilon)\gamma}{\varepsilon}\left(\frac{H}{d_c}\right)^n \qquad (11)$$

n — an exponent that accounts for the discrepancy of the phenomena occurring in a real bed from the theoretical course of the phenomenon;

Mn^2 — the Margulis number characteristic of the effect of dust collection from an aerosol in its flow around a single bed element.

From the experimental data obtained using equalizing calculus the n exponent values were found, which are: for polystyrene, $n = 0.25$; gravel, $n = 0.6$; quick coke, $n = 0.28$.

It can therefore be said that the increase in collection efficiency (equation (10)) with the bed height H is more pronounced for granular beds composed of elements of the gravel type for which the coefficient of shape is close to 1.0 (cf. the table).

Attention will be called to the fact that the beds formed from spherical elements exhibit less deviation from theoretical assumptions.

On the basis of the study made, using equalizing calculus, the following criterion equations have been developed for the dust collection process on granular elements:

— for polystyrene

$$Mo^1 = 2.8 \times 10^2 (Re)^{-0.012} (Stk)^{0.07} (Fr)^{0.104} (Po^1)^{0.021} \quad (12)$$

range studied: Re = 15–152; Stk = 3–22; Fr = 0.45–45;

$$Po^1 = (1.6–16) \times 10^1; \; P = 7.6–11.05$$

mean square error of the collection efficiency equation (10) $\delta_1 = \pm 8\%$

— for gravel

$$Mo^1 = 2.06 \times 10^{15} (Re)^{-1.075} (Stk)^{2.849} (Fr)^{11} (Po^1)^{-1.021} \quad (13)$$

range studied: Re = 29–235; Stk = 1.13–9.0; Fr = 0.34–15.5;

$$Po^1 = (5–24.4) \times 10^1; \; P = 14.7–22.5$$

mean square error of the collection efficiency equation (10) $\delta_1 = \pm 9\%$

— for quick coke

$$Mo^1 = 1.6 \times 10^{-17} (Re)^{-1.013} (Stk)^{-1} (Fr)^{0.003} (Po^1)^{1.01} \quad (14)$$

range studied: Re = 31–266; Stk = 0.98–7.9; Fr = 0.31–13.4;

$$Po^1 = (3.5–27.9) \times 10^1; \; P = 0.87–0.96$$

mean square error of the collection efficiency equation (10) $\delta_1 = \pm 1.5\%$

As mentioned before, the study was made for an aerosol of technical talc dust of the equivalent diameter of its particles $d_r = 17.66 \times 10^{-6}$ m at the ambient temperature of $t = 20°C$.

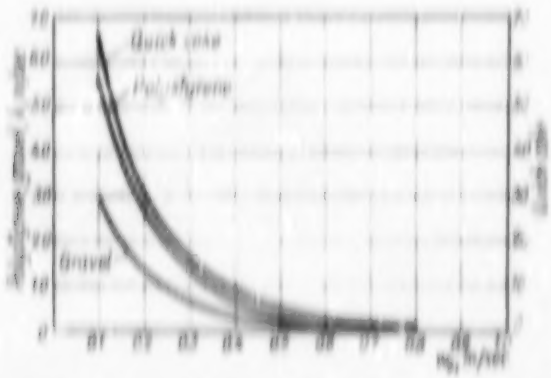

Fig. 4. Collection rate coefficient, k, for polystyrene, gravel, and quick coke

On the basis of the equations derived the following general conclusions can be made:

— collection efficiency decreases with growing Reynolds number (Re);

— the beds formed from smooth-surface elements (polystyrene, gravel) feature higher collection efficiency with higher Stokes and Froude numbers;

— the bed formed from coarse-surface elements features turbulent flow of aerosol around its particles and the whirls produced result in that the diffusive mechanism of collection predominates, whereas the effect of the inertial and gravitational mechanism decreases with flow rate;

— the beds formed from irregular elements (quick coke) have higher collection rate coefficients k (Fig. 4), whereas beds composed of regular elements possess a more favorable structure expressed by parameter P.

Resistance to Flow through Granular Beds

Determination of the resistance to flow through a granular bed that represents a specific filtration structure is essential for a correct choice of fan performance to be used in the dust control system. There are a number of equations available in the literature [5], [6] which are useful in determination of resistance to gas flow through a granular bed. Nevertheless, these equations provide results that are considerably discrepant compared with experimental data. Based on the study on the resistance to gas flow of polydisperse beds composed of the irregular-shape elements it has been found that the capillary model of the bed is the most valid in fitting to and interpreting of the experimental data. For the unit length of the channel the pressure drop is given by equation

$$\Delta p/l_e = \lambda_e \eta w^{2-n} w \tag{15}$$

The equation upon ordinary transformations may be reduced to the form

$$\Delta p = \lambda_e \frac{H}{d_e} \cdot \frac{w^2}{2} \varrho \cdot \frac{(1-\varepsilon)^2}{\varepsilon^3} \quad \text{N/m}^2 \tag{16}$$

The resistance to gas flow was studied for bed of the materials investigated (polystyrene, gravel, and quick coke) for a bed height of $H = 50$–200 mm.

The equivalent flow resistance coefficient for the capillary model is described in terms of equation

$$\lambda_e = \frac{A}{\mathrm{Re}_e} + \frac{B}{(\mathrm{Re}_e)^2} + D \tag{17}$$

During the work-up of the data it was realised that term $B/(\mathrm{Re}_e)^2$ is critical for the value of flow resistance coefficient λ_e. The term is responsible for the effect of curvatures of the equivalent capillary channel and for the effect of multiple coalescence of adjacent channels. The effects of the resistance of straight sections (A/Re_e) and of the entrance and exit (D) effect are negligible.

Based on the results of experiments and the use of equalising calculus the following individual equations were derived:
— for polystyrene

$$\lambda_z = \frac{61.4}{(Re_z)^{0.91}} \tag{18}$$

the Re_z range studied, 11–104.5, mean square error, $\delta_\lambda = 5.26\%$
— for gravel

$$\lambda_z = \frac{277.4}{(Re_z)^{0.88}} \tag{19}$$

the Re_z range studied, 34.8–272, and $\delta_\lambda = 3.5\%$
— for quick coke

$$\lambda_z = \frac{2873}{(Re_z)^{0.98}} \tag{20}$$

the Re_z range studied, 142–1106, and $\delta_\lambda = 6.58\%$.

A considerable scatter of values of the characteristic properties of the bed and of equivalent Reynolds numbers under the same flow rates w_z that are maintained constant makes it impossible to derive a general equation for the flow resistance coefficient λ_z (Fig. 5).

Fig. 5. Equivalent flow resistance coefficient, λ_z, for polystyrene, gravel, and quick coke beds.

It is however generally true that the effect of the Reynolds number is similar and the B value shows a general trend to increase with equivalent diameter d_z, which is for polystyrene, gravel, and quick coke, $d_z = 6.625 \times 10^{-3}$, 1.9257×10^{-2}, and 12.59×10^{-2} m, respectively.

Low flow resistance is typical of granular beds for which the parameters defining the bed structure $(1-\varepsilon)\psi/\varepsilon^3$ in equation (16) have a low

value, the value being approximately for polystyrene, gravel, and quick coke 16.7, 10.5, and 0.87, respectively. Quick coke also exhibits the lowest values of the resistance to gas flow of the materials examined.

Conclusions

Based on the results of the study it was realized that the description of collection efficiency and flow resistance of various granular beds in terms of a universal equation is unfeasible because of the specific nature of effect of individual bed properties of the bed elements (ε, ψ, coarseness). The equations derived may be fulfilled merely for certain groups of granular materials of similar properties.

Analysis of the study performed makes the formulation of the following general conclusions possible:

— in the aspect of high collection efficiency and simultaneous low flow resistance as a target, coarse-surface elements should be used for filtration beds in industrial devices; the bed particles should additionally exhibit irregular shape and an equivalent diameter of $d_z = (4\text{–}6) \times 10^{-3}$ m;

— increased bed height only slightly affects the collection efficiency, but results in a substantial rise in flow resistance; however, in view of the need to extend service life of the filtration bed, recommended bed height should be $H \geq 180 \times 10^{-3}$ m;

— collection efficiency above 90% is possible for loads of the filtering surface up to ca. 1800 m³/m²hr.

Notation

$a' = a/\varepsilon$ — surface area of the capillary channel walls related to a unit volume of channel

$a = [6(1-\varepsilon)\psi]/d_z$ — specific surface of the bed, m²/m³,

c_p, c_k — initial and final aerosol concentration, respectively, kg/m³

D — dust diffusion coefficient, m²/sec

$d_z = 1/\Sigma(x_i/d_i)$ — equivalent diameter of the element of granular bed, m

d_i — mean diameter of dust fraction of the mass share of x_i, m

d_p — equivalent diameter of dust particle, m

$d_k = 4\varepsilon/a$ — equivalent diameter of the capillary channel, m

F — filtration bed surface, m²

g — acceleration of gravity, m/sec²

H — granular bed height, m

k — dust collection rate coefficient, m/sec

k_0 — a constant

l_0 — length of the straight section of the capillary channel, m

w_0 — aerosol flow velocity related to effective cross section of filter, m/sec
w — gas flow velocity in the capillary channel,, m/sec
ρ_g — gas density, kg/m³
ρ_p — dust density, kg/m³
η — dynamic viscosity of gas, Nsec/m²
ν — kinematic viscosity of gas, m²/sec
ε — bed porosity, m³/m³
ψ — shape coefficient of the bed elements
$Ma^2 = k/w_0$ — Margulis number
$Re = d_z \rho_g w_z / \eta$ — Reynolds number
$Stk = p \rho_p w_z / d_z \eta$ — Stokes number,
$Fr = w^2/d_z g$ — Froude number
$Pe^2 = d_z w_z / D$ — Péclet number
$Re_z = w_z d_z / \nu$ — equivalent Reynolds number.

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PRELIMINARY RESULTS OF THE STUDIES ON THE EFFICIENCY OF SOME DEMISTING SYSTEMS

(Wstępne wyniki badań skuteczności wybranych układów odemglających)

Results of laboratory investigations are reported for Tarflen-network and polystyrene-ball demisting systems. The gas flow rate was found to affect demisting efficiency for individual systems. The most advantageous demister system was advanced.

The rapid development observed recently in the chemical and related industries as concerns process intensification brings about, among other effects, considerably increased entrainment of dispersed liquid phase from the apparatus operated with the liquid and gas phase transport. The entrainment of liquid droplets by gas not only entails loss of the liquid but it additionally results in catalyst poisoning, fouling of pipelines and of the following apparatus of the train, contamination of final products, finally in pollution of the atmosphere into which such a liquid is discharged together with off gases. To prevent these adverse effects, special devices are being increasingly used which precipitate the disperse airborne liquid phase from the flowing gas stream. The devices in point are known as inlet eliminators or demisters. Until today in view of the lack of domestic equipment of that kind, in justified cases import demisters were used. Otherwise, some untypical and not always adequate own designs [1] were used occasionally.

In the Tarnów Nitrogen Plant the production of network demisters of Tarflen[TM][2] fiber has recently gone on stream. Considerable interest in these devices expressed by manufacturing plants, the requirements the devices should meet, and rather substantial differences in the design

[1]The Institute of Industrial Equipment and Power Engineering, Cracow Technical University.

[2]The domestic equivalent of teflon.

parameters of the demister packs produced as compared with the import counterparts, had given the incentive to take on a series of tests to obtain general information on their usefulness and to develop some guidelines for their correct designing [3].

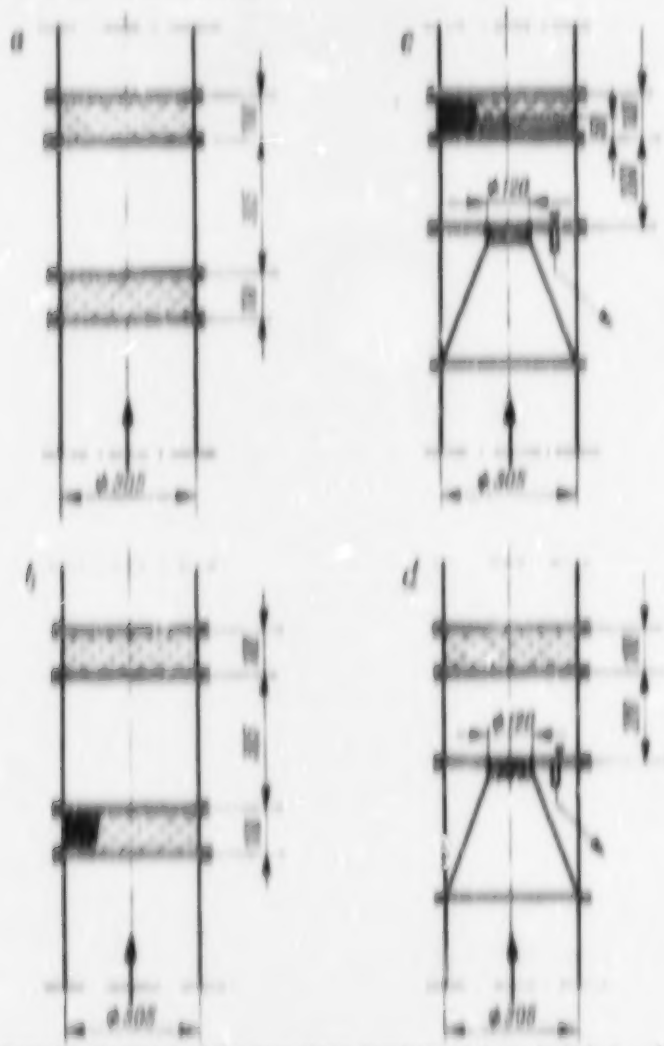

Fig. 1. Schematic diagrams of the two-stage demister systems tested: a — both stages are the Turnów type network packs; b — 1st stage 80- and 10-mm balls, 2nd stage the network pack; c — 1st stage 40-mm balls, 2nd stage 30- and 10-mm balls; d — 1st stage 40-mm balls, 2nd stage a network pack

The results presented below are concerned with a preliminary series of tests carried out on the network demister packs manufactured by the Tarnów Nitrogen Plant (Fig. 1a), and on the double-bed polystyrene-balls demister (Fig. 1c). Moreover, considering a higher resistance of the ball bed to contamination with dust carried with the gas, some systems were examined that were a combination of both demister types mentioned. The demister packs tested are schematically shown in Fig. 1.

Figure 1a illustrates a system of a two-stage demister in which both the first and the second stage were network packs. Figure 1b shows a demister system employing the balls 25 and 10 mm in diameter and a network pack as the first and second stages, respectively. In the demister presented in Fig. 1c the first stage was made of a single bed of balls 40 mm in diameter, while the second one, of loose ball bed with balls 25 and 10 mm in diameter. Shown in Fig. 1d is a two-stage variant in which the first stage are the balls 40 mm in diameter, and the second one constitutes a network pack.

The three basic types of demister packing tested are characterized below.

The Tarnów type pack was composed of a layer of loosely stacked flat nets accommodated in an envelope of fine gauze to form the whole of a total height of about 100 mm. The nets were knitted on a knitting machine from Tarflen fiber of a noncircular cross section of a thickness of 0.4 to 0.5 mm, and the average mesh size was 5 mm. The pack thus formed was of a porosity of 90%. In case the balls were used, the demister system consisted of two separate beds of different characteristics. The first bed was composed of balls 40 mm in diameter with some of the balls cut to fit the space near the walls one by another in a ring of a diameter of 120 mm (Fig. 1c). The bed was designed to set up conditions favoring coalescence of the droplets of the flowing mist. The second bed, of a total height of 100 mm and serving the purpose of a proper filtration bed, was made up by pouring successively balls 25 mm in diameter to a height of 50 mm, followed by 10-mm balls. Both the first and the second double-ball layer were held between securing nets to prevent their possible lifting away by the flowing gas stream. Average porosity of the top bed was ca. 93%.

Measuring Setup

The tests aimed to determine the effect of gas flow rate upon demisting efficiency of individual demister systems and to measure resistance to gas flow of such demisters, were carried out with the laboratory experimental setup illustrated on the scheme in Fig. 2. The demister packs tested were

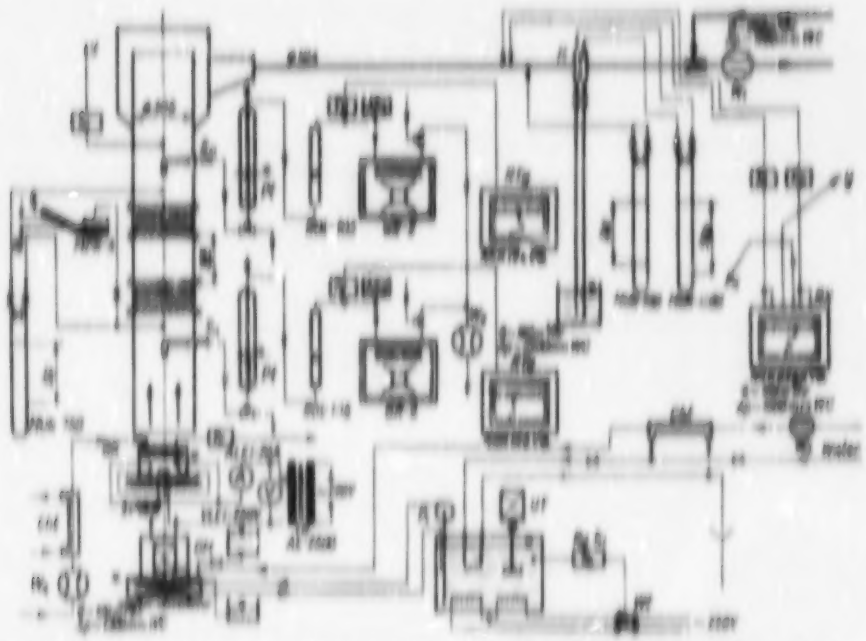

Fig. 3. Diagram of the laboratory setup for testing demister systems: *GK* — condensation generator; *GM* — mechanical generator; S_0 — measuring probe; *K* — orifice plate; *W1-1* — fans; *GR-6* — gas meters; *ROT.* 105 — rotameter; *Pl* — fluidized-bed scrubber; P_1 — ultrathermostat pump; *RTg* — gas temperature recorder; *RE* — the wet — and dry — bulb thermometer (humidity measurement); *MUR* 150, *MUR* 1500 — U-tube pressure gages; *UT* — ultrathermostat; *Chl* — water cooler; *MPR* 4 — inclined-tube micromanometer; *Rg Tu* — temperature control; *TR* — autotransformer; T_k — gas temperature in the column; T_c — liquid temperature in the mist generator; T_g — gas temperature in the gas meter; T_0 — liquid temperature in ultrathermostat; T_s — dry-bulb thermometer reading; T_m — wet-bulb thermometer reading; Δp_g — pressure drop in gas meter; Δp — gas pressure drop across the filter packs tested; Δp_k — pressure drop across the measuring orifice plate; p_{st} — static pressure of gas in the pipeline

accommodated in a 350-mm plexiglass column. Air flow was induced using a fan fitted downstream of the orifice plate on the outlet line from the column. The air, along with the test liquid mist generated, was aspired into the column from the bottom.

Glycerol was used to generate the test mist. Initially a mechanical mist generator was employed which was subsequently replaced by a condensation type unit. The mist produced by the mechanical method was polydisperse, of a comparatively large drop size (above 10 μm), which in consequence resulted in demisting efficiency of nearly 100%. During the

preliminary tests no effect of varying gas flow rate upon the demisting efficiency was noted. Only when the condensation mist generator was used, which produced almost monodisperse mist of a droplet size below 5 μm, the effect of the gas flow rate upon demisting efficiency could be evaluated.

In the mist concentration measurement system fluid-bed scrubbers were employed, in which glycerol was washed out with distilled water. Concentration of the scrubbing solution withdrawn from the scrubbers was determined refractometrically in terms of the index of refraction, n_D^{20}. Demisting efficiency was calculated as the ratio of the difference in mist concentration in the air down- and upstream of the demister to the mist concentration in the outgoing air. The air flow rate in the column was varied every 0.5 m/sec. The upper limit of the rates used depended on the demister type employed and was restricted by the effect of enhanced reentrainment of droplets from the flooded pack.

With the attempts at reproducibility of the results, efforts were made to maintain a possibly constant value of the initial mist concentration at the inlet to the column, by adjusting the quantity of the glycerol turned into mist in a unit time.

Results

The results of the testing obtained are gathered in the table, where

W_s — the gas flow rate in the column related to the empty column cross section,

B_p — the initial concentration of the mist at the demister entrance,

Δ_p — the pressure loss of gas in the demister systems tested,

η_{av} — the average overall demisting efficiency of the demister system examined.

Table

Results of the Tests on Demisting Efficiency and Resistance to Gas Flow of the Demisters Studied

W_s m/sec	B_p g/m³	a		a'		b		c		d	
		η_{av} %	Δ_p mm W.C.	η_{av} %	Δ_p mm W.C.	η_{av} %	Δ_p mm W.C.	η_{av} %	Δ_p mm W.C.	η_{av} %	Δ_p mm W.C.
0.5	4.1-5.0	83.0	5	86.2	7	93.1	76	86.5	28	91.5	32
1.0	3.9-5.0	86.9	17	90.1	31	96.9	336	86.5	123	94.7	116
1.5	1.9-3.8	86.0	42	91.2	74	—	—	87.2	440	96.9	248
2.0	1.7-1.9	89.4	73	89.0	137	—	—	—	—	—	—

The values of efficiency η_m and resistance to flow Δ_p are reported for the respective demister systems in the table in columns a to d. Individual letters refer to analogous lettering adopted in Fig. 1, and in column a the data refer to a single pack of the Tarnów type network demister.

The values given in the table are averages from individual measurement series. The lack of figures for certain gas flow rates is due to the effect of flooding of the pack observed at those rates. Despite the adjustment of the generator delivery provided, a constant mist concentration at the entrance to the column could not be achieved. In consequence, the initial mist concentration ranged from 1.7 to 5.0 g/m³. The adjustment ensured merely a fairly reproducible mist concentration within the flow rates of gas in the column used. The gas temperature during the measurements varied over an interval of 37–55°C.

Conclusions

Results of the tests performed allow merely for some qualitative conclusions to be made, as the individual values of both demisting efficiency and resistance to gas flow refer exclusively to the conditions of the measurements made. This is primarily due to the fact that glycerol used in the study, even though ensuring fine and fairly monodisperse mist, has the properties much differing from those of the liquids encountered in industrial practice.

The study has demonstrated, however, a clear-cut effect of the gas flow rate upon the demisting efficiency of the systems in point. This is related to the quantity of the liquid arrested on the filtration bed, and the increase in efficiency is observed with increasing amount of the liquid withheld up to a certain limiting value.

It follows from the observations made that of particular advantage is the case when the first demister stage is overloaded compared with the second stage in a system with two filtration beds. This is corroborated by results of tests which indicate that the highest efficiencies were achieved for the two-stage demister system, in which the first stage was a bed of balls 33 and 10 mm in diameter, of a porosity of 32%, and the second stage was a Tarnów network pack of a porosity of ca 90%.

On the other hand, the study failed to substantiate the expected effect of coalescence of mist droplets in the demister system employing a single bed of large balls 40 mm in diameter. This can be seen from comparison of the results of efficiency of a single network pack with the two-stage 40-mm balls-network pack system.

Further studies on the effect of overload of the first stage on the demisting efficiency of the network-pack two-stage demister appears advis-

able. Expectedly, for mist of lower viscosity liquid, compared with glycerol, much higher maximum flow rates will be possible than those achieved in the present tests.

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Comparison of the Criteria for the Determination of Protection Zones Conforming to the Regulations in Poland with Those of Other European Countries

The sanitary protection zone assigned to a manufacturing plant to be observed for the sake of air pollution control is understood as the area surrounding that plant over which the pollutants discharged should become diluted to such an extent that on the border of the protection zone the GLC standards should not be exceeded. A secondary purpose of the protection zones is to protect the area surrounding the plant against other effects of its industrial activity such as noise and vibrations, liquid waste disposal, microbiological and radiation hazards.

To achieve desirable results, the area of a protection zone should be duly developed by afforestation, planting shrubs, or by cultivating such plants for which the effect of the nuisance due to the manufacturing plant is not harmful or else they do not carry along some secondary hazards like human health hazard. Moreover, the areas of protection zones should not be inhabited nor there should be located any buildings or facilities designed for a permanent residence of humans, which are not directly connected with the production or services of the plant.

The problem of protection zones is not widely recognized in other European countries. The literature data and publications on this subject are rather scarce and incomprehensive.

This article is concerned with the problem of protection zones as it known in France, Great Britain, the USSR, Israel, and the Federal Republic of Germany.

The Legislature Concerning the Determination of the Protection Zones in Poland

The pertaining regulations in force in Poland specify protection zones and special protection zones. By these notions are to be understood the territory of this country with the exclusion of the premises of industrial

plants and their protection zones. For those areas threshold limit values have been set up for the major air pollutants. The values are allowed to be exceeded over the protection zone areas, but on their borders on the areas under protection or special protection the values should attain the standard level.

The regulations concerning the guidelines in demarcating protection zones are based upon the principle of subdivision of manufacturing plants into five groups depending upon the productic i type. The zone width for particular groups is as follows: group 1 — 1000 m, group 2 — 500 m, group 3 — 300 m, group 4 — 100 m, group 5 — 50 m. The zone width is measured as a straight line from the emission source. The classification adopted accounts merely for the air pollution control aspect. None of the Polish regulations does specify how to account for, and what is the effect of other neighbor polluting plants. Thus the only criterion in determining the protection zone of a given manufacturing plant is its own polluting activity.

The regulations permit of other zone width than specified for a given production kind and volume in justified cases. Of the conceivable excuses may be the climatic and topographic conditions, concentrations of the substances released and the reach of their dispersal, and the process and control equipment involved.

The Problem of Protection Zones in France and Great Britain

In these countries the question of insulation of the environment against the nuisance and harmful effects of the activity of industrial plants does not reflect itself in the standing regulations in the same form as it is the case in Poland. The problem is, however, taken into consideration under certain rules and laws related to the siting of industrial plants relative to towns, settlements, and other forms of residential areas. In the regional planning three functional zones are distinguished, such as residential, commercial and industrial ones. Their mutual situation depends upon the results of theoretical calculations of dispersal of pollutants, measurements of their concentrations, and local physiographic conditions. The major goal of those activities is to achieve a minimum possible adverse effect of industrial pollution upon the population.

Protection Zones in the USSR

In that country industrial plants were subdivided into five classes as early as 1957. The division is based upon the kind of atmospheric pollutants discharged, the manufacturing process used, and the pollution control

equipment provided. The classes vary in width, like in the Polish regulations, from 1000 to 50 m. Here again the range of a protection zone may be suitably reduced or extended if this is required because of technological conditions or natural conditions that affect the GLC values. In the areas where sanitaria, rest homes, or centers requiring special protection are located, the zones must be extended twice or even three times relative to the range provided for a given type and size of the manufacturing plant.

From the legal point of view the zones are meant as the standard to be observed. The only criterion in their determination is the air pollution control.

The regulations also provide the manner in which the area contained within the zone should be utilized, as well as the type of development admitted on that area. A recommended development there is vegetation, and the selection of suitable plants depends, among others, upon the susceptibility of species to air pollution.

Protection Zones in Israel

The question of maintaining clean air in the vicinity of industrial plants gave rise to the issuance of the guidelines for the determination of so-called buffer zones in that country. The guidelines are valid in law and are held as the official state standards.

The following six groups are provided for manufacturing plants with respective zone width:

- group 1 — no zone specified,
- group 2 — zone width of 50 m,
- group 3 — zone width of 150 m,
- group 4 — zone width of 500 m,
- group 5 — zone width of 1000 m,
- group 6 — zone width of 2000 m.

In singular cases the zones may be doubled or tripled in width.

Although not quite apparent from the regulations, in the determination of the above zone width not only air pollution control aspect was taken into account but also other hazards as noise or explosion hazard.

The Problems Related to the Determination of Protection Zones in the Federal Republic of Germany

The question of a suitable siting of industrial plants with respect to residential areas from the viewpoint of protection of their inhabitants against harmful effects of industrial activity has been given attention

Fairly long ago in the Federal Republic of Germany, in 1948, a list of the minimal distances to be observed between residential areas and industrial plants was published under the authorship of Reichow. This list is referred to as the shielding scale. The criteria considered by Reichow in setting up these guidelines for nearly 80 plant types are not fully known. He took into account, however, such nuisances of an industrial plant as smoke, soot and dust emission, and noise. The span of the distances specified for various industries is substantially diverse, the smallest being 50 m and the largest 5000 m, while the intermediate distances differ sometimes very insignificantly, e.g., 100, 110, and 130 m.

The shielding scale in point is not a legal act and has no validity in law in the Federal Republic of Germany. This could therefore be used in practice merely as a sort of guidelines for a correct siting of industry relative to residential developments. However, to give the government supervision authorities the power to pass siting decisions in regional planning, protection zones have been specified for certain industries by the Minister of Labor, Health and Welfare in 1975. These are merely guidelines like the shielding scale, but they constitute a basis for approval of the siting of industrial plants.

The distances determined, depending on the industry type, range from 300 to 2000 m with a 5% tolerance allowance downward. The protection zones provided in the regulations do not allow for the specific physiographic conditions of the area. The width of the protection zone demarcated according to the principles provided in the regulations is to ensure adequate protection for the population against air pollutants and vibrations. Thus the two kinds of nuisances were taken into consideration in specifying the zone width for individual production types.

Summary of the Guidelines in the Protection Zone Determination

The guidelines in the determination of the protection zones for industrial plants in various countries covered here are hardly comparable and too far-reaching analogies cannot be drawn on their basis.

The protection zone widths were developed under different conditions specific for a given country, as concerns the manufacturing processes and industries used. For that reason, in the plant listing in one country one can see the industries not encountered in the listings of other countries. Specifically, in the Polish and Soviet listings a great many processes of chemical industry are given a fairly detailed attention. As opposed to the former, in the Israel's standards and in the Reichow specification there is

much less of such processes, whereas in the West German regulations practically entire chemical industry is treated as a whole under the entry: great chemistry including petrochemistry.

Many differences are also present in the zone width specified for the same industries. For example battery works are assigned after Reichow — 500 m, after the Israeli standards — 100 m, similarly in the Polish and Soviet standards — 150 m; iron foundries of a capacity above 30,000 t/year: in Israel — 1000 m, by Reichow — 400 m, Poland and the USSR — 500 m, tanneries, in Poland and the USSR — 100 m, the Federal Republic of Germany — 800 m, in Israel — up to 5000 m. Apparently, the differences are appreciable, which, apart from the reasons mentioned above, may be due to the difference in the approach to the question of protection of inhabited areas. This is actually reflected in a diverse treatment of the threshold limit values assumed as standard (different sanitary standards of the threshold limit values). Also different are technical possibilities and equipment of industry with the waste gas pollution control devices, as well as climatic and topographic conditions and factors. These are unquestionably not all the factors involved, but it can be admitted that it is those elements that are critical in the fact that we now observe the differences between individual countries as concerns their standards for the protection zone widths.

More detailed analysis of this problem is unfeasible in view of the lacking rational for the procedure in determining the protection zones adopted. It should, however, be emphasized that in certain cases the zone widths provided for the same industries are the same in different countries. For instance in the pertaining regulations in Poland, the USSR, and Israel the same zone width is stipulated (1000 m) for such industries as calcium carbide, chlorine, sulfuric acid, or superphosphate manufactures.

Conclusions

The following conclusions can be made from the above discussion:

(1) There is no theoretical, scientific basis for the specification of the protection zone width for various industries;

(2) There are no universal criteria to form a basis for taking into account other nuisances due to the manufacturing activity of a plant, besides atmospheric emission;

(3) The problems mentioned in points 1 and 2 would require some research to be done;

(4) It would be worthwhile to verify the listing of protection zones

for Polish conditions on the basis of a possibly obtained results of that research;

(5) The listing in force in Poland should be supplemented with the industries that have not been encompassed there but which critically affect the sanitary condition of the environment, like boilerhouses, thermal power plants, enamel shops, electroplating plants, paint shops, etc.

Prepared by Wojciech Ostrowski, M.Sc., Eng.

PATENT REVIEW

A Method of Dust Precipitation from the Exhaust Gases from a Furnace for Combustion Especially of the Brimstone-Flotation Sulfur-Bearing Waste or Pyrite and the Train of Equipment for the Application of that Method

Inventors: T. Sanetru, B. Tobi-sewest, L. Hillebrand, F. Betlej, B. Hillebrand
Patent owner: the Siarkopol Brimstone Mine and Processing Plant Combine, Tarnobrzeg
Filed: February 18, 1972
Cl.: 24g, 6 01
Provisional Patent No. 77403

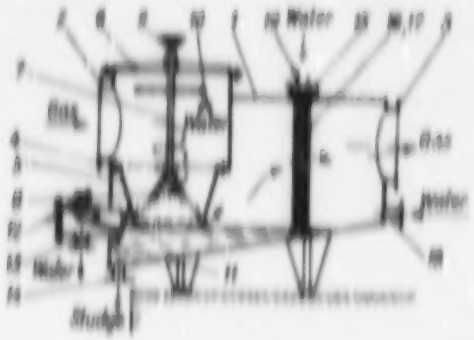
The object of invention is a method of dust precipitation from the exhaust gases from a furnace for combustion especially of the brimstone-flotation sulfur-bearing waste or pyrite and the train of equipment for the application of that method. The waste or pyrite stock is burnt to produce sulfuric acid. The equipment train for the application of that method ensures a high degree of the cleaning of the gases, which will provide improved economic and process indices. In the method for dust precipitation, according to the invention, the known techniques are employed such as static, kinetic and gravity dust precipitation through spraying. For the precipitation of the finest dusts a wet coagulation combined with the kinetic precipitating of the coagulated particles adopted is followed by drying in a known way. The equipment train for the application of said method incorporates on the side of the coarse dust precipitation stage for example a static precipitator, cyclones or multicyclones, a waste-heat boiler, and a scrubbing tower, and contains at least one coagulator and known drying equipment. The coagulator is equipped with preferably adjustable guide vanes, and spraying nozzles mounted within the area of the vanes.

p. p.

A Device for the Removal of Emissions from a Gas

Inventors: J. Strzelski, A. Nowak
Patent owner: Chemadex Complete Industrial Plants Assembly and Delivery, Cracow
Filed: August 16, 1973
Cl.: 13e, 2/01
Provisional Patent No.: 75833

The invention is designed for a wet emission control technique of a contaminated gas, especially air. The device for emission control consists of a housing (*1*) of an elliptical shape in the horizontal cross section. In the lateral front section of housing (*1*), parallel to the major ellipse axis, the dirty-gas inlet stub pipe (*2*) is eccentrically fitted, and opposite to inlet stub pipe (*2*) the outlet stub pipe (*3*) for clean gas is provided. A conical tube (*5*) that reaches to the water surface is vertically mounted on a collar (*4*) attached to the housing (*1*). A cone (*8*) is attached to the cover (*6*) of the housing (*1*) by means of a rod (*7*) in such a way that its base points downward, and said rod (*7*) is mounted at the apex of that



cone (*8*). The position of the cone (*8*) with respect to water surface can be adjusted by a knob (*9*). Owing to this the width of the slit between the cone edge and the edge of tube (*5*) can be continuously adjustable during operation of the device. Above the cone (*8*) an annular water sprayer (*10*) is provided which enables a prehumidification of the gas. The water level adjustment is achieved by means of a rotary valve (*11*) connected to the water level control system (*12*). The excess of water is drained through stub pipe (*13*), and the sludge formed is discharged through stub pipe (*14*). In the middle section of the device, parallel to the minor ellipse axis, the rod-type partition is provided, which is composed of vertical rods (*16*) made of an acidproof material and wrapped in a packing, preferably with

asbestos rope (*17*). The water is fed through stub pipe (*18*). The water flushing the rod-type partition is supplied by means of stub pipe (*19*). The device is lined inside with vulcanized rubber coating not shown in the figure.

P.P.

A Flexible Suction Nozzle

Inventor: A. Wyrwals
Patent owner: Bipromet Nonferrous Metallurgy Designing Office, Katowice
Filed: October 1, 1974
Cl.: B1e, 66
Provisional Patent No: 61748

The object of invention is a flexible telescopic suction nozzle designed for pneumatic conveying powder and fine-grain material, and especially for materials from dumps to be conveyed to tanks. Typically the nozzle and the tank are incorporated in the design of a device that moves along the dump. The object of invention in the example of the design as shown in the figure is in a longitudinal cross section. The nozzle consists of a top external duct (*1*) connected with tank (*2*) and it is attached in a swinging way by means of a flexible joint (*3*) to the lower duct (*4*) and section (*5*) provided with guide rings (*6*). Lower duct (*4*) and section (*5*) along with guide rings (*6*) are joined with screws (*7*) to ring (*8*). In guide rings (*6*) a telescopic duct (*9*) is provided on which a rotary flange (*10*) and suction funnel (*11*) are mounted. Telescopic duct (*9*) along with suction funnel (*11*) are suspended from cables (*12*) which are trained around the pulleys (*13*). A cushion spring (*14*) is provided between ring (*8*) and telescopic duct (*9*). Flexible joint (*3*) is held between plates (*15*) bolted together with screws (*16*). Rotary flange (*10*) consists of a stationary section (*17*) and rotary section (*18*), which are supported on bearing balls by means of a rigid housing (*20*), as well as of internal sealing (*21*) and external sealing (*22*).

The negative pressure produced in top duct (*1*) and in telescopic duct (*9*) is relieved at the exit to suction funnel (*11*), because the ducts are gas-tight along the entire length of the device. The gas tightness is secured by flexible section (*3*), guide rings (*6*), and rotary flange (*10*). The sinking and lifting of the telescopic duct (*9*) is achieved by means of cables (*12*), whereas the shocks are absorbed by spring (*14*). Bottom duct (*4*) can be moved off the vertical owing the flexible section (*3*) within

the range limited by the screw heads and nuts. Suction funnel (*11*) can be moved around the axis of the device on the bearing balls provided in the rotary flange (*10*).

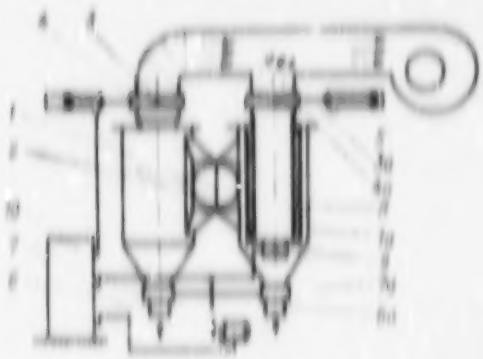
P.P.

A Dust Precipitator

Inventors: A. Lepiarczyk, F. Cyganek
Patent owner: Stanislaw Staszic Academy of Mining and Metallurgy, Cracow
Filed: November 4, 1974
Cl.: 50e, 3/01
Provisional Patent No.: 80017

The object of invention is a dust precipitator for gases. The device, according to the invention, is shown on the example of execution in the figure in a partial vertical section. The precipitator consists of cyclone

collectors (*1*) and (*1a*) connected with inlet stub pipes (*2*). The outlet stub pipes (*3*), (*3a*) of collectors (*1*) and (*1a*) are equipped with flaps (*4*) and (*4a*) and are connected in parallel with exhauster (*5*). Dust disposal stub pipes (*6*) and (*6a*) are, on the other hand, provided with rotary valves (*7*) and (*7a*). Inside collectors (*1*) and (*1a*) layer filters (*8*) are accommodated,



each of which is provided with a vibrator designed to shake the dust off the filter surface (*9*). Flaps (*4*) and (*4a*) and rotary valves (*7*) and (*7a*) combined with vibrators (*9*) are coupled to a known automatic control system (*10*). During the operation of the dust precipitator, according to the invention, the precipitation of coarse dust from the dust-laden gas takes place on the inner surfaces of cyclones (*1*) and (*1a*), whereas the fine cleaning is achieved in layer filters (*8*). The automatic control system (*10*) enables operation of the precipitator with only one functioning collector (*1*) or (*1a*). Then in the collector put out of service layer filter (*8*) can be subjected to regeneration.

P.P.

CHRONICLE

The Emission Control Equipment for the Electroplating Plant Off Gases

On March 9, 1976, in Zabrze, a conference was held on the Emission Control Equipment for the Electroplating Plant Off Gases. The event was organized by the Section of the Emission Control Technology and Atmospheric Protection of the Polish Association of Sanitary Engineers, Katowice branch, and by the plant section of that Association at the Ponar-Biprom Warsaw, Zabrze branch. The conference covered a number of problems, the main points of the reports are presented below.

The Question of Environment Protection in Designing Electroplating Plants — Z. Burzym, J. Postolko, A. Tolesiński, J. Truss

The report was concerned with the following subjects:

— emission of toxic substances from the chemical and electrochemical metal processing departments and the devices for the treatment of the exhausted air;

— permissible concentrations of substances in the atmospheric air over the protected areas;

— emission of substances in the electroplating and chemical processes;

— the use of fluidized-bed own-liquid bed scrubbers, involute demisters and helicoidal demisters for the cleaning of the ventilation air from the electroplating shop in the Ponar Metal Works in Tarnów.

The Stalagmometric Method of Determination of Optimal Detergent Concentration in the Foam Scrubber Liquors Used for Purification of the Electroplating Shop Off Gases — Z. Burzym, T. Lanowska, J. Truss.

In the report attention is called to the essential need to treat the off gases discharged into the atmosphere by electroplating plants. The off gases include oxides of nitrogen, hydrogen cyanide, hydrogen chloride chromic acid mists, gaseous organic compounds, etc.

The off gases can be freed from those compounds by means of such measures as:

— dry cleaning methods, in which the adsorbing medium is an

active fixed bed; the methods require periodical replacement of the adsorbent to recover the latter, they are usually expensive, require auxiliary equipment, and the process involved is as a rule laborious;

— wet cleaning methods, where the absorbing medium is water or aqueous solutions of chemical compounds or suspensions that react with the gas absorbed; for the removal of certain toxic compounds from the gases occasionally the cocurrent foam scrubbers are employed for the operation of which suitable foaming agents are critical.

The Research Methods for Planar Demisters as Concerns Their Geometrical Structures and Physicochemical Properties of the Medium — Z. Burzym, T. Laniewska, J. Trusz

The authors make a point right from the beginning that the major objective of the demisters now in industrial use is to determine demisting efficiency and their resistance to gas flow. The devices involve an unattended operation for a long time (about two years). The discordance among the demister users and manufacturers of that equipment, coupled with a tremendous demand from industry, especially from the sulfuric acid manufactures, and a very high price of the imported demisters, gave the incentive to enhanced research and development effort in this field. A prototype demister design has become a target of such effort. From the research done the following conclusion was drawn:

— the finer the mesh of the demister network, the higher the demisting efficiency.

Separately covered was the question related to the study of demisting efficiency for the gases containing dusts accompanying sulfuric acid mist.

The conference was concluded with a discussion pertaining to the problems covered in the reports.

J.K.

The Economic Problems of the Natural Environment Protection in the Investment Activities

Sponsored by the Voivodship Section of the Polish Economical Society in Gdańsk a national scientific conference was held in that city on March 4–5, 1976, on the Economic Problems of the Natural Environment Protection in the Investment Activities. The following three reports were delivered on the first day of the proceedings:

— The Economic Measures and Rationale for the Natural Environment Protection of the Port of Gdańsk Area and Adjacent Areas — Professor Dr. W. Andrusiewicz (Maritime Institute, Gdańsk);

— The Problems and Economic Questions of the Environment Protection in the Project Designing — E. Ostrowski, Dr., BISTYP Research and Designing Center of Building Industry, Warsaw;

— Problems and the Engineering and Process Possibilities for the Protection of the Environment — D. Chomica, Dr. Eng., BISTYP Research and Designing Center of Building Industry, Warsaw.

A discussion followed the lectures. A total of 51 participants represented the government administration bodies, designing offices, educational institutions of the highest rank, research institutes, and manufacturing plants.

The second-day proceedings were opened by Dr. A. Langer, the Gdańsk voivode, with a review of the problems of protection of the natural environment in the Gdańsk voivodship.

The conference participants visited the Northern Port and the Gdańsk Oil Refinery.

In conclusion of the conference a resolution was made in which, among others, it has been postulated that "at the stage of the project designing there are exceptionally good opportunities to ensure a reasonable management with natural resources, which may manifest itself both in the process of the accomplishing of the project and during its operation." It has been also stated that "the current status is the threat to the natural environment and the problems related to the environment protection quite often exceed the frontier of this country. The problems should be the subject of immediate consideration on the international level, and in particular within the COMECON countries."

The conference participants put the sponsors under obligation to turn the resolution to the pertinent party and state authorities.

Z.B.

The Manufacture and Deliveries of the Air Pollution Control Equipment

In May 25, 1976, at the Voivode's Office in Katowice, a symposium was held on the Manufacture and Deliveries of the Air Pollution Control Equipment, sponsored by the KLIMA-WENT Ventilation, Air Conditioning and Emission Control Equipment Industry Branch in Katowice and the OPAM Air Pollution Control Equipment Designing and Delivery Enterprise, Katowice. The following topics were covered in the reports delivered.

Filtration Equipment for the Removal of Emissions from Industrial Gases — E. Nowak.

The author reviewed the design and principles of operation of two types

or fabric filters: FDI type designed for heavy-duty applications, and B type suitable for light process conditions. Some attention was also given to a new type dust collector whose serial production has just gone on stream, notably the pulse filter in which woven filter fabrics have been replaced by nonwoven packs and the filtering process has been reversed. The new type filter features higher dust and gas loads, elimination of all types of mechanisms like rappers, guide vanes, and a simpler automatic control system.

Mechanical Emission Control Devices — A. Latala

Reviewed in the report are the most widely used dry mechanical emission control devices, cyclone collectors. The reasons for the popularity of this type of collectors are given, namely, low capital and operating costs, simple design and easy maintenance, relatively small size, considerable reliability, and hardly any failure hazard due to the lack of moving parts.

Subsequently, the commonest and the most widespread cyclone types are discussed in detail, notably:

— B type cyclone, manufactured by the Końskie Kowent and designed by Instalprojekt;

— D and De type cyclones, made by the Końskie Kowent;

— CN-15 cyclone of the design from the Soviet NIIOGAZ Institute;

— OC-1 and OC-2, and OC-3 type cyclones, designed and produced by Energomontaż, Chorzów, under the license of the WALTHER company;

— C-41 cyclone designed and tested at the Institute of Thermal Technics, Łódź, and produced by Końskie Kowent.

A group of cyclone collectors of a somewhat more involved design is characterized, notably multicyclones which are composed of from a few to several scores of small-size cyclones accumulated in a common housing. The most popular and manufactured always by the same companies are:

— MO and MOR types;

— multicyclones produced under the LURGI license;

— OMW type multicyclones under the WALTHER license.

Manufacture, Deliveries and Application of the Wet Emission Control Devices and Systems — E. Świeszek

The author gives an account of the current production of the wet-type emission control devices and their applications, and specifies major performance data of the devices and of some systems. The wet emission control devices manufactured are subdivided into four groups, notably:

(a) spray collectors, are featured by low hydraulic resistances, and includ-

— complete-evaporation scrubber, under the LURGI license,
— hydrodynamic spray scrubbers of OHD type.

(b) inertial separators, featured by medium hydraulic resistances, such as:

— impingement separators of MU type,
— wet cyclones,
— radial-flow collectors (LURGI license),

(c) sparging scrubbers, featured by low to medium hydraulic resistances:

— MB orifice-type scrubbers of new design,
— foam scrubbers denoted as PPOI,

(d) devices designed for dust removal from dust-generating equipment such as those used for:

— sonic screens,
— fettling plants,
— grinders and grinder-polishers.

Attention is called to the fact that great effects from the dust control operations by wet techniques, i.e., high collection efficiency and adequate reliability of device, can be achieved not only upon a correct selection of the device and a good design of the emission control system, but when the former are accompanied by a necessary adjustment of the system coupled with the entrusting the maintenance and operation of the system to adequately trained personnel throughout its whole service.

The Production Potentialities and the Range of Services as Concerns the Emission Control Equipment Manufactured by KOWENT — J. Sipika.

Information is provided on the Kowent Air Pollution Control and Ventilation Equipment Works in Kańskie, its current and future production potentialities, the ordering procedure, delivery availabilities, and the range of services which the plants can offer to its customers.

Manufacture of Electrostatic Precipitators (Electrofilters) in the KLIMAWENT Industry Plants — E. Zgraja

The author covers general performance principles and the advantages of electrostatic precipitators (electrofilters). The design of the most widely used precipitator is described in detail namely, the dry-type horizontal device, along with its uses in individual processes. Another type of the precipitator treated at considerable length is a wet-type horizontal one which is used in a number of manufacturing processes wherever wet technique of the emission control is recommended because of the properties of the gas-dust system. The electrostatic precipitator types reviewed are merely typical examples of the cleaning of gases using electrostatic

precipitators, but they do not exhaust the potentialities inherent in this technique.

The Devices and Systems for the Removal of Gaseous Contaminants from Gases — J. Koniecznyński

In the report attention is called to the fact that the design of the emission control devices for gaseous effluents depends to a high degree on the treatment techniques adopted, and the techniques are grouped as follows:

— absorption techniques, based on the effect of absorption of gaseous contaminants in a liquid,

— adsorption techniques, which involve adsorption of noxious gases, vapours, or fumes on a developed surface of solid adsorbents,

— catalytic oxidation (combustion) techniques.

Subsequently, a brief characteristic is given for the most typical devices designed for the cleaning of the gaseous effluents from hydrogen chloride, hydrogen fluoride, fumes of inorganic acids and their anhydrides. This equipment includes:

— packed towers,

— spray towers,

— foam scrubbers,

— Venturi scrubbers.

A separate and comprehensive treatment refers to the problems regarding the sulfur dioxide emission control, and a statement is made that the material collected in this field and the information possessed permit to offer some designing services in this branch of technology.

Organisation and Prospects for the Development of Production of the Dust Precipitation and Gaseous Emission Control Equipment in the Rawent Air Pollution Control and Ventilation Equipment Works — collective report.

The accomplishments in the production of the air pollution control equipment are presented. A number of prototype devices have been made at Rawent over the years 1971–1975. They include:

— a modernised bag fabric filter,

— electrostatic precipitator for sintering lines,

— a wet electrostatic precipitator with a plastic lining,

— a TWUR high-pressure bag filter,

— a wet collector with the radial water feed.

Put on the manufacturing line have been:

— modernised bag fabric filters,

— dry- and wet-type electrostatic precipitators made under a license,

— electrostatic precipitators for the sulfuric acid plants,
— cyclone collectors, single and battery types.

A specialization program has been developed to include the manufacture of such units as:

— electrostatic precipitators (electrofilters) made under license exclusive of the power-industry types,
— fabric filters,
— gaseous emission treatment devices,
— dry and wet mechanical collectors in a wide range of capacities.

Much attention is paid in the report to the question of the engineering level of the emission control equipment produced, by which the following should be understood:

— proper selection of the emission control system,
— design of the emission control system,
— design of the emission control devices,
— manufacture of the emission control devices,
— assembling of the emission control devices,
— putting into operation of the devices,
— testing and warranty and operation measurements of the emission control equipment.

Emphasis is put upon the necessity to divide the production into two groups depending on the production process used, notably, the steel structures, which do not require the integrity of the manufacturing process at large, and then it is immaterial who designs, who assembles, and who uses the structures. On the other hand, the second group, broadly defined as industrial equipment, does not tolerate similar approach as the previous group does.

Significance of Research in the Field of the Cleaning of Gases from Particulate and Gaseous Contaminants — *J. Piekarczyk*

Emphasis is put on the necessity of a rapid development of production of the air emission control equipment that results from the constantly developing industry. It was pointed out that the gas cleaning technology is a remarkably experimental field. For that reason in this technology tests and measurements are of prime significance. General research can be divided into the following:

— basic research,
— experimental station tests,
— design study,
— acceptance tests of devices or plants,
— check tests.

Such tests and research are always laborious and expensive. Never-

theless, they are in the final effect economically sound. It should become a routine practice to commission the emission control equipment only following the acceptance tests to be carried out in a close cooperation with the representatives of the buyer, designer, assembly and measurement team. Only then the equipment will be properly operated and the capital costs incurred will bring effects in terms of reduced pollution of the atmosphere.

The OPAM Katowice Enterprise — the General Supplier of the Dust and Gaseous Emission Control Equipment for Industrial Effluents — *J. Operhalski*

The conditions under which the specialist enterprise of OPAM Air Pollution Control Equipment Designing and Delivery was organised are related along with the situation in the state of equipment of that type in that period in Poland. Presented subsequently are the changes that followed over the period of 1971–1978 mainly due to the calling into existence of the KLIMA-WENT Industry Branch which are:

— an over tenfold increase in turnover and an analogous rise in the quantity of the equipment on the weight basis;

— the turn from small-size devices and plants of comparatively simple deign and low efficiency to large-size, high-performance and long-life equipment featuring the performance characteristics close to the world standards which meet the needs of all the major industries for that kind of equipment;

— acceptance of the delivery orders for all the major industries all over the country and contacts with the major buyers in individual industry branches.

Additionally attention is called to the fact that the attitude of the buyers to the machines and equipment purchased is not always correct. This manifests itself, among others, by

— carelessness as concerns proper protection of the equipment on storage, that is, in the period from the date of their purchase to the moment of assembling and service,

— lack of adequate checking upon the completeness of the equipment received,

— assembly of the equipment is carried out at dates that substantially differ from those planned for a given investment task.

The report is terminated with the formulation of major objectives and further trends in the development of this activity.

J.K.

REVIEW OF PAPERS

338. Rose, A., The Cost of Stack Gas Cleaning in New York State — JAPCA, No. 10, 1975, p. 1005–1008.

The study made demonstrated that over the industrial areas of the State of New York in 1972 a total of 1596 emission control units were operating. The cost of the units was 272.8 million dollars. The number and the cost of the emission control devices used in individual industries are specified in two tables. It was estimated that the cost of the emission control equipment for the most annoying industries will amount to 1481 million dollars on a nationwide scale in 1977.

340. Bruckman, L., Rubino, R. A., Asbestos — Rationale behind a Proposed Air Quality Standard — JAPCA, No. 10, 1975, p. 1007–1015 (5 figs., 2 tab.).

Since the asbestos dust poses a serious health hazard, the standard for its airborne concentration should be strictly determined. The asbestos consumption in 1970 in the United States was 800 thousand ton, and its airborned dust in urban air reached 30 ng/m³. The major sources of asbestos emission and the method of the determination of its content in the air are discussed.

341. Granitzer, H., Heizkraftwerke eine umweltfreundliche Energieversorgung — Energie, No. 11, 1975, p. 381–389 (7 figs., 4 tab.).

Discussion of the emission sources and suggested measures to prevent excessive pollution of the environment is followed by the conclusion that the emission can be reduced by the development of thermal power plants. The power obtained in the heat-power process requires, with an allowance for all the losses, ca. 1050 Kcal/kWh, which is 50% of the value of a modern conventional plant. Under the same emission control equipment provided, the quantity of gases released is likewise half as high as that discharged from conventional power plant. The methods of desulfurization of various fuels and exhaust gases are also covered.

343. Lillis, E. J., Young, D., EPA Looks at "Fugitive Emissions" — JAPCA, No. 10, 1975, p. 1015-1018 (1 tab.)

The problem of so-called *fugitive* emissions is discussed. As the particulate and gaseous emissions from manufacturing processes are also discharged through doors, windows, ventilation holes, etc., and thus not captured by the emission control devices, and they impair the air quality, EPA suggests the development of a program for an effective emission control for such sources.

343. Messtechnische und rechnerische Ermittlungen von Immissionskonzentrationen im Einflussbereich von Grossemittenten als Bewertungsgrundlage für die Territorialplanung — Energietechnik, No. 3, 1975, p. 98-100 (3 figs., 3 tab.)

A meteorological and analytical method is presented for the determination of the ground level concentrations of particulate and gaseous emissions around major power units and the like emitters. Examples are given for mathematical simulation of the changes caused by new emitters set up on the area of a definite distribution of emissions. The examples are illustrated by similar practical solutions used in the German Democratic Republic.

J.M.

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